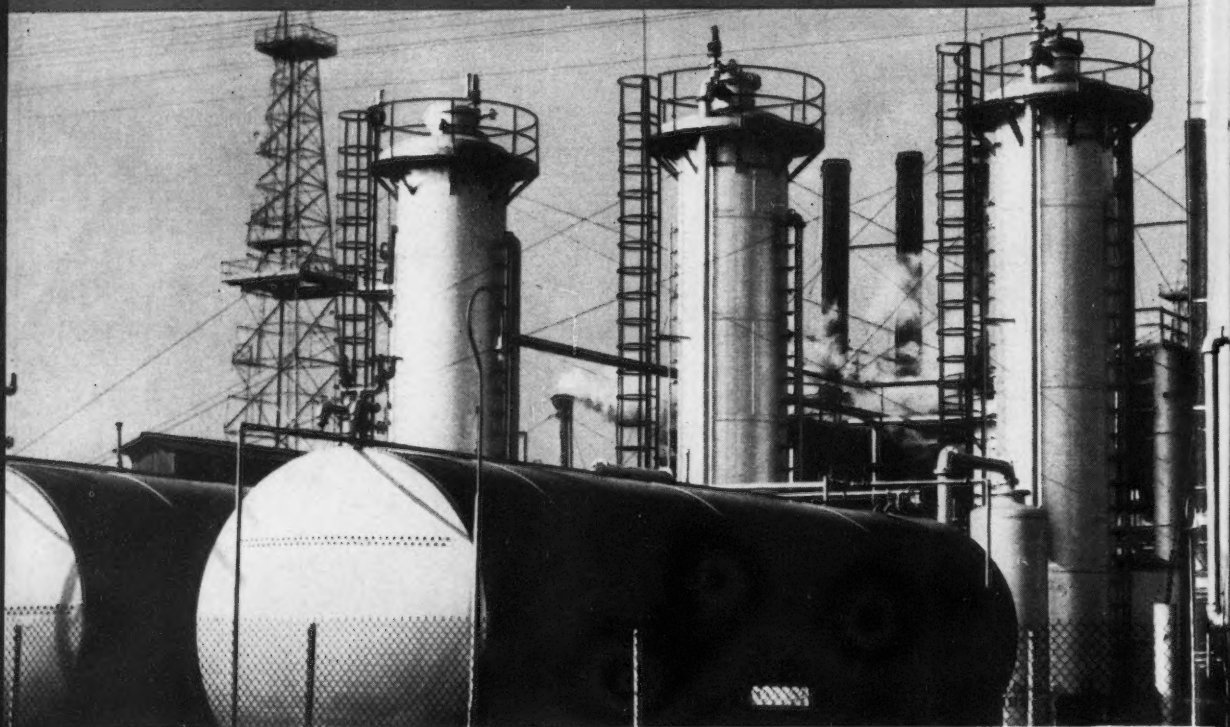


Corrosion



There's more to CORROSION than meets the eye



Sometimes VISIBLE... Often HIDDEN... Corrosion Strikes in Every Plant

This year, American Industry will pay more than \$6,000,000,000 for losses created by corrosion... *yet much of this corrosion may never be discovered* until it's too late to protect—and time to pay!

Corrosion is readily detected when it appears as rust layers or failing paint on exposed surfaces. But, by far, the major costs of corrosion come from hidden areas—where only minute inspections and constant care can prevent costly failures.

YOU LOSE IN A "WAITING GAME"

Don't wait for rust or other visible signs to appear. Visible or hidden, corrosion will destroy costly equipment... halt production... cause unnecessary maintenance shutdowns... and contaminate valuable products. Thus, corrosion dips deep into your profits as it creates needless losses totaling thousands of dollars.

YOU CAN PREVENT NEEDLESS WASTE

Check your plant for corrosion's presence. Double-check areas that are vulnerable to *hidden corrosion*. If you would like help, an AMERCOAT Field Engineer will gladly assist you in making a thorough analysis. There is no obligation.

FOLLOW THE LINE OF *resistance*... PROTECT WITH *Amercoat!*

AMERCOAT CORPORATION

4809 FIRESTONE BLVD., SOUTH GATE, CALIFORNIA

CHICAGO, ILL.

NEWARK, N. J.

JACKSONVILLE, FLA.

DALLAS, TEX.

What is AMERCOAT?
AMERCOAT is a method of corrosion control. Not just a single product, but a complete LINE of coatings, individually formulated to solve or prevent specific industrial corrosion problems.

COAL CHEM

CORROSION



Every drum of
PITT CHEM
 Modified Enamel

*Measures up to
Written Specifications*


You don't have to buy a single drum of Pitt Chem Modified Enamel to recognize its uniform top quality. Just check its specifications . . . softening point . . . penetration . . . ash, etc., and you'll *know* that an enamel that meets these rigid standards *has* to give you top performance, in application and in service.

Ton after ton, these impervious enamels perform uniformly within specifications. Pitt Chem Modified Enamel consistently heats up faster, flows better from kettle to pipe, coats more pipe per day and stands up to a wide range of temperature conditions. And, thanks to this same PITT CHEM *quality-insurance*, you can't beat this tough, durable enamel for downright, long-lasting protection. • We'll gladly supply you with technical data on request. Write today!

- ★ Standard Grade Tar Base Enamel
- ★ Modified Grade Tar Base Enamel
- ★ Plasticized Grade Tar Base Enamel
- ★ Cold Applied Tar Base Coatings

W&D 4447 B

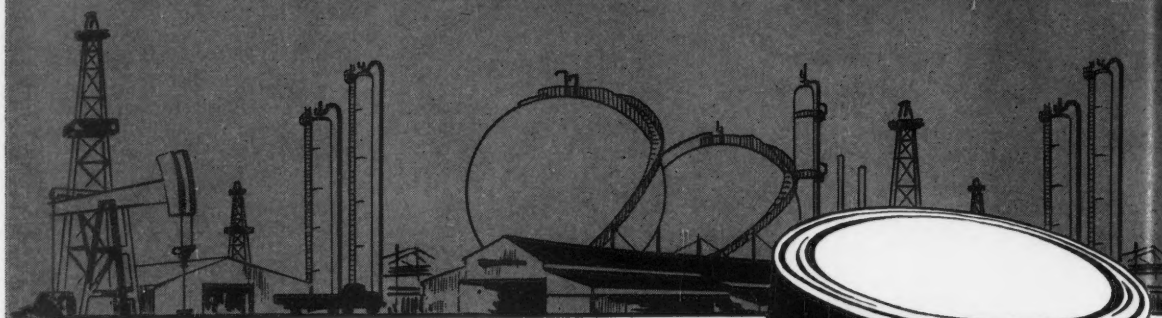
PROTECTIVE COATINGS DIVISION



PITTSBURGH
 COKE & CHEMICAL CO.

Green Building - Pittsburgh 15, Pa.

TESTED AND PROVED



"COPON", the new
Coast-formulated epon resin
coating for positive protection
of metal surfaces . . .



"COPON" is now giving industry a truly remarkable new kind of protection against rust and corrosion from chemical fumes, acids, caustic alkali and salt water. And it is combining its revolutionary protective qualities with other such desirable features as (a) remarkable elasticity, (b) exceptional long life, (c) phenomenal tenacity to all types of metals.

May we give you more facts — or send you sample for your own testing?



Available in Primers, Finishing Enamel and Paints in all Colors.



COAST Paint & Lacquer Co. Inc.
P. O. BOX 1113 • HOUSTON, TEXAS

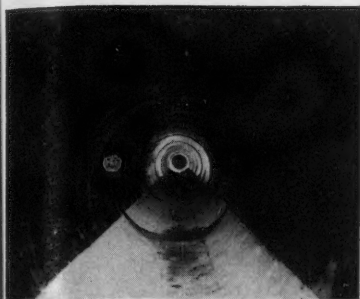
THIS MON
line has tw
a molded v
protects th
densation p
Sewer vapo
sewer cond
sulfuric aci
the life of a
and was m
coat Corpo

E D
IVY M
EDITO
GEORGE DI
THOMAS P
F. N. ALQU

C C
C. L. B
R. W. I
J. J. H
W. E. I
HUGO V
GUSTAV
R. H. B
DERK H
H. O. SA
R. MCF
L. M. M
T. E. LA
E. A. T

B U
NORMAN
to
A. B. C
ta
ag

1061 M
Subscription: \$9.
\$7.50, of w
Corrosion: S
atories and lib
ual copies to
100. Foreign r
ental or express
the U. S. for
tered as second
et Office at H
1879.
Corrosion is Ind



THIS MONTH'S COVER—This 48-inch sewer line has two-thirds of its upper area lined with a molded vinyl chloride liner plate. The lining protects the concrete against corrosive condensation products from acid or alkaline sewage. Sewer vapor space condensation under septic sewer conditions can contain up to 5 percent sulfuric acid. This inert lining is designed for the life of a sewer under inaccessible conditions and was manufactured and installed by Amercoat Corporation, South Gate, Cal.



EDITORIAL STAFF

IVY M. PARKER—Editor

EDITORIAL REVIEW COMMITTEE

GEORGE DIEHLMAN, *Chairman*
THOMAS P. MAY J. W. RYZNAR
F. N. ALQUIST ARTHUR W. TRACY

CORRESPONDENTS

C. L. BULOW—*Non-Ferrous Metals*
R. W. FLOURNOY—*Pulp, Paper, Mining and Food*
J. J. HALBIG—*Ferrous Metals*
W. E. HUDDLESTON—*Petroleum Production and Pipe Lines*
HUGO W. WAHLQUIST—*Power*
GUSTAVE HEINEMANN—*Chemical Process*
R. H. BROWN—*Light Metals*
DERK HOLSTEYN—*Petroleum Refining*
H. O. SAUNDERS, JR.—*Telephone, Telegraph, Radio*
R. MCFARLAND—*Non-Metals*
L. M. MOSHER—*Transportation Industry*
T. E. LARSON—*Fresh and Salt Water*
E. A. TICE—*Editor of "Corrosion Problems"*

BUSINESS STAFF

NORMAN E. HAMNER, *Managing Editor and Advertising Manager*
A. B. CAMPBELL (*Executive Secretary NACE*) *Business Manager*

GENERAL OFFICES

1061 M & M Building, No. 1 Main St.
Houston 2, Texas

Subscription: \$9.00 per year to non-members; Member's \$7.50, of which \$3.75 are applied as subscription. Concession: Special rate, \$4.00 per year for public libraries and libraries of educational institutions. Additional copies to members 50 cents, to non-members, \$1.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U. S. for an equivalent amount in U. S. funds. Entered as second class matter October 31, 1946, at the Post Office at Houston, Texas, under the act of March 3, 1879.
Corrosion Is Indexed Regularly by Engineering Index.

Corrosion

devoted entirely to
CORROSION
research and control



Published Monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., as a permanent record of progress in corrosion control.

Vol. 9

February, 1953

No. 2

CONTENTS

Directory of NACE Regional and Sectional Officers	iv, v
Directory of Technical Practices Committees	viii, ix
Officers and Directors, National Association of Corrosion Engineers	xiv

TECHNICAL SECTION

A Short Cut for Corrosion Researchers	45
The Corrosion of Domestic Galvanized Hot Water Storage Tanks By I. L. Newell	46
Discussion: Kenneth F. Knowlton, Page 49	
Economic Aspects of Cathodic Protection By Ray M. Wainwright	51
Effect of Heat Treatment and Related Factors On Straight Chromium Stainless Steels By F. K. Bloom	56
The Coupon Technique—A Valuable Tool in Corrosion Testing By H. L. Bilhartz and Howard E. Greenwell	66
Discussion: C. M. Schwab, Page 72; Reply by H. L. Bilhartz and H. E. Greenwell, Page 73	

DISCUSSIONS

Corrosion of Metals in Fluorine and Hydrofluoric Acid by G. C. Whitaker	
Discussions by Kempton H. Roll, Robert R. Pierce, Ward E. Pratt, Page 74; G. A. March, Edward Kauck, G. H. McIntyre, F. A. Prange, Page 75; Replies by G. C. Whitaker, Pages 74, 75.	
Aluminum Alloys for Offshore Pipelines by E. T. Wanderer and Donald O. Sprowls. Discussion: Bryant West Bradley, Robert L. Bullock, Page 75; Reply by Edward T. Wanderer, Page 75.	

NACE REGIONAL AND SECTIONAL NEWS

	Page		Page
Southern New England Section		S.E. Region to Meet	4
Is Organized	3	Jack Battle Elected Tulsa Section Head	4
Interim Executive for Canada Named	3	Teche Sees Inco Film	4
Philadelphia Section Elects Brink,		Spalding Names New N. Texas Committees	5
Hears Luce on High Alloys	3	San Francisco Section Names New Officers	5
NACE Calendar	3	149 Register for Western Region Meeting	6
Best Heads Region	3	Preventive Inspection Urged as Means	6
Von Lossberg Is Elected	3	European Corrosion Research Described	8
Fontana to Speak	3	Corrosives' Effect on Stone Revealed	8
NACE Officers Will Take Over March 20	4	Maintenance Costs Reduced by Inhibitors	8
Kansas City Section Officers Nominated	4	New Plastic Materials Reduce Corrosion	8
Olive New Chairman at Shreveport	4	Condenser Tube Alloys Discussed at Houston	9
		Tulsa Short Course Set March 4-6	40

GENERAL NEWS OF CORROSION INTEREST

	Page		Page
Topic of the Month—Aluminum		New TP Committee on Plastics Formed	5
Coiled Tube		Spectrographers Seek Papers for Symposium	9
By Edward T. Wanderer	1	Ewing and Burns to Receive Awards for 1953	10
British Seek Speaker on Cathodic Protection	4	Electrochemical Society to Meet April 12-16	16
Inter Society Corrosion Calendar	5	New Products	51

NINTH ANNUAL CONFERENCE AND EXHIBITION SECTION

	Page		Page
Bustling Chicago Offers Variety	13	Small Groups Will Discuss	
Technical Program Includes 41 Papers	14	Pipe Line Corrosion	32
Diversified Exhibition Planned	14	Conference Registration Will Open March 15	32
4 Papers to Be Given on Electrode		Power, Communications Session Has 5 Papers	34
Potentials	18	Well Inhibitors, Casing Corrosion Are Topics	36
Ewing Heads Arrangements Group	20	Four Cathodic Protection Papers	
Authorities on Pipe Line Coatings		Are on Program	38
Will Speak	22	Two Discussions to Be Held March 19	40
Fresh and Salt Water Symposium		2 Sessions Set for Chemical Industry	
Has 5 Papers	24	Symposium	42
NACE Central Office Will Have Exhibit	26	Coatings Symposium Covers Diverse	
Refinery Symposium Features		Material	46
Discussion Session	26	Three Educational Lectures Planned	50
Elevated Temperature Papers			
Give Vital Data	28		

INDEX TO CORROSION ABSTRACTS

INDEX TO ADVERTISERS

Copyright 1953 by the National Association of Corrosion Engineers. Reproduction of the contents, either as a whole or in part, is forbidden unless specific permission has been obtained from the Editor of Corrosion. Articles presented represent the opinions of their authors, and not necessarily those of the Editors of Corrosion, nor the Officers or Members of the National Association of Corrosion Engineers. Manuscripts to be considered for publication should be forwarded, together with illustrations, to the Editor of Corrosion, 1061 M & M Building, Houston 2, Texas.

Directory of NACE Regional and Sectional Officers

NORTH EAST REGION

L. B. DONOVAN, Director
Consolidated Edison Co.
of New York, Inc.
4 Irving Place
New York City.

GEORGE E. BEST, Chairman
Mutual Chem. Co. of America
1348 Block St.
Baltimore 31, Md.

KEMPTON H. ROLL, Vice-Chair.
Lead Industries Assoc.
420 Lexington Ave.
New York 17, N. Y.

W. R. BRIGGS, Sec.-Treas.
W. A. Briggs Bitumen Co.
3303 Richmond St.
Philadelphia 34, Pa.

Baltimore Section

L. G. VON LOSSBERG, Chairman
Sheppard T. Powell Consulting
Chemical Engineers
330 North Charles Street
Baltimore, Maryland

ALLEN L. ALEXANDER, Vice-Chair.
Naval Research Laboratory
Washington 25, D. C.

RISQUE BENEDICT, Sec.-Treas.
Naval Research Laboratory
Washington 25, D. C.

Greater Boston Section

EDWIN J. TITSWORTH, Chair.
Koppers Co., Inc., Tar
Products Division
250 Stuart St.
Boston 16, Mass.

JOHN SWIFT, Vice-Chairman
Arthur D. Little, Inc.
30 Memorial Drive
Cambridge 42, Mass.

J. D. BIRD, Sec.-Treas.
The Dampney Co.
1243 River, Hyde Park
Boston 36, Mass.

Metropolitan New York Section

GEORGE C. HULL, JR., Chair.
Anglo-American Varnish Co.
55 Johnson St.
Newark 5, N. J.

MORTON BERMANN, Vice-Chair.
Brooklyn Union Gas Co.
197 St. James Place
New York, N. Y.

F. J. LeFEBVRE, Sec.-Treas.
Electro Rust-Proofing Corp.
Box 178
Newark 1, N. J.

Philadelphia Section

E. G. BRINK, Chairman
American Viscose Corp.
Marcus Hook, Pa.

H. H. BENNETT, Vice-Chair.
Socony-Vacuum Oil Co., Inc.
Paulsboro, N. J.

J. S. PETTIBONE, Sec.-Treas.
Am. Sec. Testing Mat.
1916 Race St.
Philadelphia 3, Pa.



Pittsburgh Section

N. P. PEIFER, Chairman
Manufacturers Light
& Heat Co.
800 Union Trust Bldg.
Pittsburgh 19, Pa.

N. T. SHIDELER, Vice-Chair.
Pittsburgh Coke & Chemical
Corporation
Neville Island,
Pittsburgh 25, Pa.

F. E. COSTANZO, Sec.
Manufacturers Light &
Heat Company
2202 Vodeli St.
Pittsburgh 16, Pa.

W. W. BINGER, Treasurer
Aluminum Co. of America
Research Laboratories
Box 772
New Kensington, Pa.

Western New York Section

WILLIAM O. BINDER, Chair.
Research Laboratories
Union Carbide & Carbon Corp.
Niagara Falls, N. Y.

J. E. SHIELDS, Vice-Chair.
Alox Corp.
3943 Buffalo Ave.
Niagara Falls, N. Y.

PAUL R. GUENTHER, Sec.-Treas.
Socony-Vacuum Oil Co., Inc.
503 Elk Street
Buffalo 5, N. Y.

NORTH CENTRAL REGION

FRANK L. WHITNEY, JR., Dir.
Monsanto Chemical Co.
1700 S. Second St.
St. Louis, Mo.

JACK H. LoPRETE, Chair.
Spray-Coat Engineers
775 S. Bay Side St.
Detroit 25, Mich.

NORMAN A. KERSTEIN, Vice-Chair.
Detroit Edison Co.
2000 Second Ave.
Detroit 26, Mich.

JAMES F. HIRSHFELD, Sec.-Treas.
Hinchman Corp.
1208 Francis Palms Bldg.
Detroit 1, Mich.

Chicago Section

C. A. VAN NATTA, Chairman
Plastic Lining Coatings
900-02 South Wabash Ave.
Chicago 5, Ill.

L. W. EWING, Vice-Chairman
Standard Oil Co. of Indiana
Pipe Line Dept.
910 Michigan Ave.
Chicago, Ill.

R. I. LINDBERG, Sec.
Sinclair Research Laboratories,
Inc.
400 E. Sibley Blvd.
Harvey, Ill.

H. W. DIAMOND, Treas.
Morton Salt Co.
120 S. LaSalle St.
Chicago, Ill.

Cleveland Section

C. N. DETRICK, Chairman
Williams & Co., Inc.
3700 Perkins Ave.
Cleveland, Ohio

W. E. BAKER, Vice-Chair.
Standard Oil Co. of Ohio
606 Standard Bldg.
Cleveland 13, Ohio

H. W. HOSFORD, JR., Sec.-Treas.
Harco Corp.
Box 7026
Cleveland 28, Ohio

Detroit Section

L. D. COOK, Chairman
Wyandotte Chemical Corp.
Wyandotte, Mich.

W. R. CAVANAGH, Vice-Chair.
Parker Rust Proof Co.
2177 East Milwaukee
Detroit, Mich.

D. F. FINLAY, Secretary
Hinchman Corporation
1208 Francis Palms Bldg.
Detroit, Mich.

P. G. COATES, Treasurer
Michigan Bell Tel. Co.
7310 Woodward Ave.
Detroit 2, Mich.

Eastern Wisconsin Section

HAROLD F. HAASE, Chair.
2917 West Juneau Ave.
Milwaukee 8, Wis.

IRVING S. LEVINSON, Vice-Chair.
Process Industries
Ampco Metal, Inc.
Milwaukee 46, Wis.

R. E. WICEN, Sec.-Treas.
Chain Belt Co. of Milwaukee
1600 West Bruce St.
Milwaukee 4, Wis.

Greater St. Louis Section

GEORGE A. FISHER, Chairman
International Nickel Co., Inc.
411 North Seventh St.
St. Louis, Mo.

OTTO H. FENNER, Vice-Chair.
Monsanto Chemical Co.
1700 S. Second St.
St. Louis, Mo.

ANDREW T. PICKENS, Sec.
C. K. Williams & Co.
2001 Lynch St.
East St. Louis, Ill.

CAMDEN A. COBERLY, Treas.
Mallinckrodt Chemical Works
316 Oak Manor Lane
Webster Groves, Mo.

Southwestern Ohio Section

ROY O. McDUFFIE, Chairman
Dept. Chem. & Met. Eng.
University of Cincinnati
Cincinnati 21, Ohio

ARTHUR D. CASTER, Vice-Chair.
Engineering Dept.,
City of Cincinnati
City Hall,
Cincinnati 2, Ohio

LEWIS M. LEDERER, Sec.
Inner-Tank Lining Corp.
1097 Wade St.
Cincinnati, Ohio

R. L. WOOD, Treasurer
Cincinnati Gas & Electric Co.
323 Plum Street
Cincinnati, Ohio

SOUTH EAST REGION

E. D. McCAULEY, Director
American Cast Iron Pipe Co.
2030 North 16th St.
Birmingham, Ala.

R. A. DAVIS, Chairman
Chicago Bridge & Iron Co.
1500 North 50th St.
Birmingham 1, Ala.

JOHN B. WEST, Vice-Chair.
Aluminum Co. of America
1818 Rhodes-Haverty Bldg.
Atlanta, Ga.

H. C. VAN NOUHUYS, Sec.-Treas.
Southeastern Pipe Line Co.
718 Forsyth Bldg.
Atlanta, Ga.

Atlanta Section

J. FLYNN JOHNSTON, Chair.
American Tel. & Tel. Co.
1139 Hurt Bldg.
Atlanta, Ga.

RAYMOND F. TRAPP, Vice-Chair.
Midwestern Engine &
Equipment Co.
3431 Sherman Road
Hapeville, Ga.

ALEX M. ERGANIAN, Sec.-Treas.
Pipe Line Service Corp.
1734 Candler Bldg.
Atlanta, Ga.

Directory of NACE Regional and Sectional Officers

SOUTH CENTRAL REGION

- T. F. P. KELLY, Director**
James E. Mavor Co.
514 M & M Bldg.
Houston 2, Texas
- H. E. WALDRIP, Chairman**
Gulf Oil Corp.
5311 Kirby Drive
Houston, Texas
- THOMAS S. MOFFATT, JR., Vice-Chair.**
Columbia-Southern Chemical Corp.
Lawrence Drive
Corpus Christi, Texas
- CLIFFORD L. BARR, Sec.-Treas.**
Shell Oil Company,
Richards Building
New Orleans, La.
- JOHN E. LOEFFLER, Asst. Sec.-Treas.**
Thornhill Craver Co.
Box 1184
Houston, Texas
- Central Oklahoma Section**
- F. W. FULLERTON, Chairman**
S. W. Bell Telephone Co.
405 N. Broadway
Oklahoma City, Okla.
- JOHN E. JOHNSTON, Vice-Chair.**
Oklahoma Natural Gas Co.
P. O. Box 1620
Oklahoma City, Okla.
- BRUCE D. OWEN, Sec.-Treas.**
S. W. Bell Telephone Co.
405 N. Broadway
Oklahoma City, Okla.
- W. H. MEIGS, Sec.-Trustee**
Phillips Petroleum Co.
2752 N. W. 21st St.
Oklahoma City 7, Okla.
- Corpus Christi Section**
- JOHN W. NEE, Chair.**
c/o Briner Paint Mfg. Co., Inc.
3713 Agnes St.
Corpus Christi, Texas
- CHARLES F. WARD, Vice-Chair.**
Magnolia Petroleum Co.
Refining Dept.
Box 1179
Corpus Christi, Texas
- JOHN P. WESTERVELT, Sec.-Treas.**
Pontiac Refining Co.
P. O. Box 1581
Corpus Christi, Texas

Houston Section

- CHARLES G. GRIBBLE, JR., Chair.**
Metal Goods Corp.
Box 1452
Houston, Texas
- L. G. SHARPE, Vice-Chair.**
Humble Pipe Line Co.
P. O. Drawer 2220
Houston 1, Texas
- G. L. DOREMUS, Sec.-Treas.**
Catholic Protection Service
4601 Stanford St.
Houston, Texas

New Orleans-Baton Rouge Section

- PHILIP B. WOGAN, Chair.**
Products-Research-Service, Inc.
521 Ave. F.
Westwego, La.
- JACK T. MARTIN, Vice-Chair.**
The Texas Company
Production Dept.
P. O. Box 252
New Orleans, La.
- FRANK S. BIRD, Sec.-Treas.**
The California Co.
800 The California Co. Bldg.
1111 Tulane Ave.
New Orleans 12, La.
- RICHARD E. MITCHELL, Asst. Sec.-Treas.**
Shell Oil Co.
P. O. Box 193
New Orleans, La.

North Texas Section

- J. C. SPAULDING, JR., Chair.**
Sun Oil Company
Box 2880
Dallas, Texas
- MORRIS BOCK, Vice-Chair.**
Sun Oil Company
1405 North Zangs Blvd.
Dallas, Texas
- MARYANN DUGGAN, Sec.-Treas.**
Magnolia Petroleum Co.
Box 900
Dallas, Texas

Permian Basin Section

- JOHNNY H. SHELTON, Chair.**
National Tank Co.
P. O. Box 665
Midland, Texas
- LAMAR F. SUDDUTH, 1st Vice-Chair.**
Stanolind Oil & Gas Co.
300 W. Illinois St.
Midland, Texas
- JAY D. STAFFORD, 2nd Vice-Chair.**
National Tank Co.
P. O. Box 665
Midland, Texas
- WILLIAM A. HOPWOOD, Sec.-Treas.**
Tnsmec Company, Inc.
2703 S. Colonial Drive
Odessa, Texas

Sabine-Neches Section

- CHRISTOPHER A. MURRAY, Chair.**
Pure Oil Company
Box 237
Nederland, Texas
- CHARLES A. RIDENOUR, Vice-Chair.**
Magnolia Petroleum Co.
P. O. Box 3311
Beaumont, Texas
- V. M. BROWN, Sec.-Treas.**
Columbia-Southern Chem. Co.
627½ Cleveland
Lake Charles, La.

Shreveport Section

- M. J. OLIVE, Chairman**
Arkansas Natural Gas Corp.
Shreveport 4, La.
- W. F. LEVERT, Vice-Chairman**
United Gas Pipe Line Co.
P. O. Box 1407
Shreveport, La.
- A. W. WHEELER, Secretary**
Graybar Electric Co.
3621 Greenway Place
Shreveport, La.
- J. O. GRIFFIN, Treasurer**
Texas Eastern Gas Trans. Corp.
Texas Eastern Bldg.
Shreveport, La.

Teche Section

- GEORGE M. HARPER, Chairman**
Union Oil Co. of Cal.
Abbeville, La.
- GUS VOGLER, Vice-Chair.**
Brance-Krachy Co., Inc.
P. O. Box 264
Lafayette, La.
- J. H. WATERFIELD, Sec.-Treas.**
United Gas Corp.
New Iberia, La.

Tulsa Section

- JACK P. BARRETT, Chairman**
Stanolind Oil & Gas Co.
P. O. Box 591
Tulsa, Oklahoma
- LLOYD NELSON, Vice-Chair.**
Shell Pipe Line Co.
1123 E. Second
Cushing, Oklahoma
- HUGH A. BRADY, Secretary**
Pipe Line Anode Corp.
P. O. Box 996
Tulsa, Oklahoma
- EDWARD A. BARTOLINA, Treasurer**
Moorlane Company
P. O. Box 1679
Tulsa, Oklahoma

WESTERN REGION

- L. L. WHITENECK, Director**
Long Beach Harbor Dept.
1333 El Embarcadero
Long Beach 2, Calif.
- E. H. GRIZZARD, Chairman**
Signal Oil & Gas Co.
811 West 7th St.
Los Angeles, Calif.
- AUSTIN S. JOY, Vice-Chairman**
Bechtel Corp., Somastic Div.
Box 457
Wilmington, Calif.
- ROBERT H. KERR, Sec.-Treas.**
Southern California Gas Co.
Box 3249 Terminal Annex
Los Angeles, Calif.
- Los Angeles Section**
- K. T. VANGSNES, Chair.**
The Vanode Co.
117 E. Colorado Blvd.
Pasadena, Calif.
- S. J. ARTESE, Vice-Chair.**
Shell Oil Company
Box 728
Wilmington, Calif.
- S. K. GALLY, Sec.-Treas.**
Southern California Gas Co.
1061 Mar Vista Ave.
Pasadena 6, Calif.

Salt Lake Section

- HARRY R. BROUGH, Chairman**
Mountain Fuel Supply Co.
36 South State St.
Salt Lake City, Utah
- GEORGE R. HILL, Vice-Chair.**
Fuel Technology Dept.
University of Utah
Salt Lake City, Utah
- JOHN W. COX, Sec.-Treas.**
Utah Oil Refining Co.
P. O. Box 898
Salt Lake City 10, Utah

San Francisco Bay Area Section

- G. A. WORKS, JR., Chairman**
Union Oil Co. of Cal.
Oleum, Cal.
- D. R. LOPER, Vice-Chair.**
Standard Oil Co. of Cal.
225 Bush St.
San Francisco, Calif.
- T. J. SMITH, Sec.-Treas.**
Electric Steel Foundry Co.
249 First St.
San Francisco 5, Calif.

CANADIAN REGION

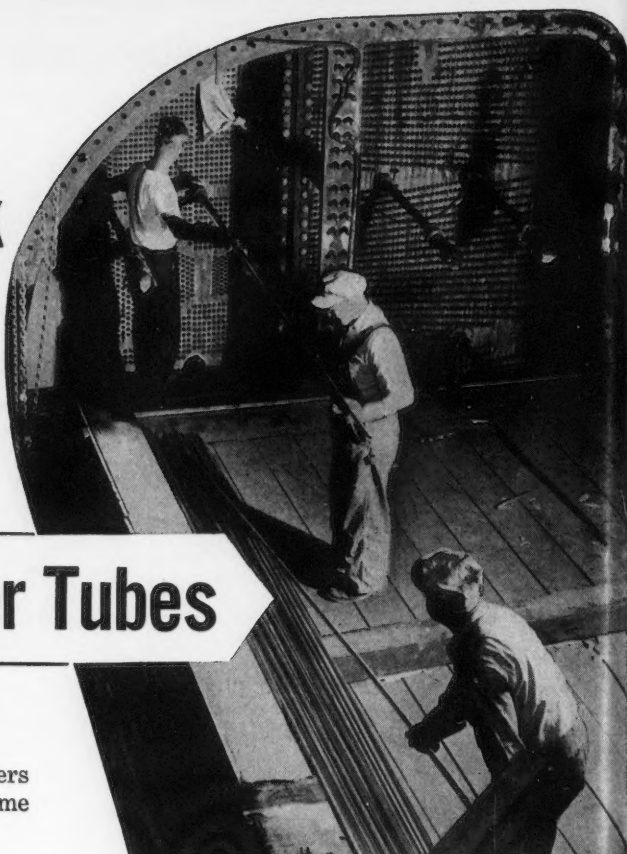
(Temporary)

- G. I. RUSSELL, Chairman**
Union Gas Co. of Canada, Ltd.
Chatham, Ontario

MANUSCRIPTS APPROVED FOR PUBLICATION

- Views of the Mechanism of Pitting Corrosion of Aluminum by P. M. Aziz, Aluminium Laboratories, Ltd., Kingston, Ontario.
- Electrochemical Behavior of Metals as a Basis for the Study of Corrosion by R. Piontelli, Politecnico di Milano.
- Kel-F Applications in Corrosive Systems by L. C. Rubin and W. O. Teeters, W. M. Kellogg Co., Jersey City, N. J.
- Present Status of Bacterial Corrosion Investigations in the United States by Carl G. Deuber, Deuber Laboratories, New York, N. Y.
- Liquid Metal Corrosion by Anton de S. Brasunas, University of Tennessee, Knoxville.
- Radiometric Study of the Adsorption Characteristics of Stearic Acid by Stanley L. Eisler, Rock Island Arsenal Laboratory, Rock Island, Ill.
- The association welcomes constructive criticism of its technical material and unsolicited technical papers on corrosion for publication in Corrosion. Authors may obtain on request a copy of the "NACE Guide for the Preparation and Presentation of Papers" which describes the association's customs and needs more fully.

One Way to Lick Corrosion and Wear of Heat Exchanger Tubes



It takes a lot of handling to retube heat exchangers . . . and while the job goes on, equipment downtime plays mischief with production.

Minimize the risk of such shutdowns. Wherever heat-transfer capacity is a factor, especially where wall thickness of tubes allows but little tolerance for effects of corrosion and erosion, specify 70-30 cupro-nickel tubes.

Thin walls of this strong tough alloy resist corrosive and erosive attacks from all sorts of cooling media including polluted, silt-laden harbor water.

Along with ability to withstand a wide variety of corrosive agents, the 70-30 cupro-nickel tubing provides outstanding resistance to pitting and stress corrosion cracking.

* * *

Aship or ashore, this alloy gives unsurpassed performance in vital parts of equipment exposed to salt water corrosion.

In power generator stations, sugar mills, oil refineries and similar plants . . . cupro-nickel alloys serve in feed water heaters, condensers, evaporators and other heat exchangers, and in oil coolers, stills, water boxes, piping, tanks, and other equipment. Cupro-nickel alloys minimize maintenance and re-

Anaconda 70-30 Cupro-Nickel Tubes, produced by AMERICAN BRASS COMPANY, Waterbury, Conn., were used to replace tubing of Admiralty Metal at the Harbor Steam Plant, Dept. of Water and Power, City of Los Angeles, Calif. View shows men retubing part of a 70,000 sq. ft. surface twin-condenser with 5,878 Anaconda cupro-nickel tubes $\frac{3}{8}$ " O.D. x 26' 3" long, serving a 75,000 KW turbine.

* * *

placement expense, loss of heat transfer capacity and interruptions of operation resulting from corrosion.

Cupro-nickel is produced in tubing, rod, strip, wire and sheet, and also in cast form. We shall be glad to give you additional information and help you select the one best suited to your requirements. Write us today.

At the present time, nickel is available for the production of cupro-nickel and other alloys containing nickel, for end uses in defense and defense supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK 5, N. Y.

ALB
ALL
ATL
BAL
BIR
BOIS
BOST
BUFF
CHA
CHIC
CINC
CLEV
COLU
DALL
DAY
DENV
DES M
DETR
EUGE
GRAN
GREEN
GREEN
HART
HOUS
INDIA
JACKS
KANS.
KNOX
LOS A
LOUIS
MEMPH

Pac

*Fiberglass
Off. of
made of

CORROSION

TALK ABOUT SERVICE!



ALBUQUERQUE, N. MEX.	MIAMI, FLA.
ALLENTOWN, PA.	MILWAUKEE, WIS.
ATLANTA, GA.	MINNEAPOLIS, MINN.
BALTIMORE, MD.	NASHVILLE, TENN.
BIRMINGHAM, ALA.	NEWARK, N. J.
BOISE, IDAHO	NEW ORLEANS, LA.
BOSTON, MASS.	NEW YORK, N. Y.
BUFFALO, N. Y.	OKLAHOMA CITY, OKLA.
CHARLESTON, W. VA.	OMAHA, NEBRASKA
CHICAGO, ILL.	PEORIA, ILL.
CINCINNATI, OHIO	PHILADELPHIA, PA.
CLEVELAND, OHIO	PHOENIX, ARIZ.
COLUMBUS, OHIO	PITTSBURGH, PA.
DALLAS, TEXAS	PORTLAND, ORE.
DAYTON, OHIO	RICHMOND, VA.
DENVER, COLO.	ROCHESTER, N. Y.
DES MOINES, IOWA	SACRAMENTO, CALIF.
DETROIT, MICH.	SALT LAKE CITY, UTAH
EUGENE, ORE.	SAN ANTONIO, TEXAS
GRAND RAPIDS, MICH.	SAN DIEGO, CALIF.
GREENSBORO, N. C.	SAN FRANCISCO, CALIF.
GREENVILLE, S. C.	SAN JOSE, CALIF.
HARTFORD, CONN.	SEATTLE, WASH.
HOUSTON, TEXAS	SOUTH BEND, IND.
INDIANAPOLIS, IND.	SPOKANE, WASH.
JACKSONVILLE, FLA.	ST. LOUIS, MO.
KANSAS CITY, MO.	SYRACUSE, N. Y.
KNOXVILLE, TENN.	TAMPA, FLA.
LOS ANGELES, CALIF.	TOLEDO, OHIO
LOUISVILLE, KY.	TULSA, OKLAHOMA
MEMPHIS, TENN.	WASHINGTON, D. C.
	WICHITA, KANSAS

Export Sales: New York
Pacific Coast Division: Santa Clara, Calif.

*Fiberglas and Coromat are trade-marks (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for products made of or with fibers of glass.

63 Owens-Corning Branches assure you fast delivery of Fiberglas Coromat* and Outer Wrap . . . Anywhere!

Geography may complicate your pipeline construction. But it doesn't limit your ability to get the most effective enamel reinforcement you can buy . . . genuine Fiberglas* Coromat and Outer Wrap. Wherever you are—wherever your pipelines go—Owens-Corning branch offices and warehouses are located nearby to give you prompt service.

Coromat gives you extra quality. Permits fast, break-free wrapping—pulls into enamel evenly to form a tough glass-reinforced coating that gives buried pipe maximum protection over the years. Fiberglas Outer Wrap, with its inorganic core of Coromat, cushions enamel against backfill shocks, soil stresses, bumps in handling. Perforated to release air and gases. Keys firmly into enamel.

Caution: All glass wraps are not Fiberglas. Let us show you the differences, and what they mean in terms of better protection for your pipelines. Contact your nearest Owens-Corning branch office. Or write OWENS-CORNING FIBERGLAS CORPORATION, Dept. 53-B, Toledo 1, Ohio.

OWENS-CORNING
FIBERGLAS

ON YOUR PIPELINES . . . FOR GOOD!

DIRECTORY OF TECHNICAL PRACTICES COMMITTEES



TED S. ZAJAC, Chairman
Shell Oil Company,
50 West 50th St.,
New York, N. Y.

EX-OFFICIO MEMBERS

MARS G. FONTANA
WALTER F. ROGERS
A. B. CAMPBELL

(Chairmen of all TP sub-committees listed below are members of the full committee)

TP-1 CORROSION OF OIL AND GAS WELL EQUIPMENT (Formerly Condensate Well Corrosion)

H. L. BILHARTZ, Chairman
Atlantic Refining Co.
Box 2819
Dallas, Texas

R. C. BUCHAN, Vice-Chairman
Humble Oil & Ref. Co.
Box 2180
Houston, Texas

TP-1A Pacific Coast, J. J. Browne, vice-chairman; General Petroleum Corp., Box 726, Wilmington, Cal.

TP-1B Condensate Well Corrosion. R. C. Buchan, Chairman, Humble Oil & Refining Co., Houston, Texas.

TP-1C Sweet Oil Well Corrosion. H. L. Bilhartz, chairman; H. E. Greenwell, vice-chairman, both with Atlantic Refining Co., P. O. Box 2819, Dallas.

TP-1D Sour Oil Well Corrosion. Co-chairmen: J. A. Caldwell, Humble Oil & Ref. Co., Box 2180, Houston, Texas, and R. L. Elkins, Shell Oil Corp., Box 1509, Midland, Texas.

TP-1F Metallurgy—Oil and Gas Well Equipment. F. A. Prange, chairman; Phillips Petroleum Co., Bartlesville, Okla.

TP-1G Sulfide Stress Corrosion. R. S. Treseder, Shell Development Co., Emeryville, Cal.

TP-1H Corrosion of Oil String Casing. Jack L. Battle, Humble Oil & Ref. Co., Box 2180, Houston, Texas

TP-1J Oil Field Structural Plastics. W. M. Thornton, chairman, Atlantic Refining Co., P. O. Box 2819, Dallas, Texas. B. W. Bradley, vice-chairman, Shell Oil Company, Tulsa, Oklahoma.

TP-2 GALVANIC ANODES FOR CATHODIC PROTECTION

WALTER P. NOSER, Chairman
Humble Pipe Line Co., Drawer 2220
Houston, Texas

H. A. ROBINSON, Vice-Chairman
The Dow Chemical Co.
616 East Grove St.
Midland, Mich.

TP-2A Correlation of Data From Operating Installations. L. R. Sheppard, Shell Pipe Line Corp., Houston, Texas.

TP-3 ANODES FOR USE WITH IMPRESSED CURRENTS

DONALD H. BOND, Chairman
The Texas Pipe Line Company
P. O. Box 2332, Houston 1, Texas

A. W. PEABODY, Vice-Chairman
263 Houston Ave.
Jackson 9, Miss.

TP-4 MINIMUM CURRENT REQUIREMENTS FOR CATHODIC PROTECTION

TP-5 CORROSION PROBLEMS INVOLVED IN PROCESSING AND HANDLING CHEMICALS

H. W. SCHMIDT, Chairman
The Dow Chemical Co.
Midland, Mich.

PAUL J. GEGNER, Vice-Chairman
Columbia-Southern Chemical Corp.
Barberton, Ohio

TP-5A Corrosion by Sulfuric Acid. C. L. Bulow, chairman; Bridgeport Brass Co. 30 Grand St., Bridgeport, Conn. W. A. Luce, vice-chairman; The Duriron Co., Box 1019, Dayton, Ohio

TP-9 CORROSION INHIBITORS

FRANKLIN M. WATKINS, Chair.
Sinclair Research Laboratories, Inc.
400 E. Sibley, Blvd.
Harvey, Illinois

ROBERT S. WISE, Vice-Chair.,
National Aluminate Corp.
6216 West 66th Pl.
Chicago, Ill.

TP-10 CORROSION FATIGUE

V. V. KENDALL, Chairman
National Tube Company, Frick
Building, Pittsburgh 30, Pennsylvania

TP-11 IDENTIFICATION OF CORROSION PRODUCTS

C. E. IMHOFF, Chairman
Research Supervisor, Chemical Lab.
Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.

TP-12 EFFECT OF ELECTRICAL GROUNDING ON CORROSION

GLEN APPLEMAN, Chairman
Pennsylvania Power & Light
Ninth & Hamilton St.
Allentown, Pa.

TP-13 ANNUAL LOSSES DUE TO CORROSION

F. N. ALQUIST, Chairman
The Dow Chemical Co.
Midland, Michigan

TP-14 INSTRUMENTS FOR CORROSION MEASUREMENTS

H. N. HAYWARD, Chairman
Engineering Experiment Station
University of Illinois
Urbana, Ill.

TP-15 CORROSION CONTROL IN THE TRANSPORTATION INDUSTRIES

K. K. KESSLER, Chairman
Baltimore & Ohio Railroad
Baltimore 23, Maryland
G. M. MAGEE, Vice Chair.
Assoc. Amer. Railroads
Technology Center
Chicago 16, Ill.

TP-16 ELECTROLYSIS AND CORROSION OF CABLE SHEATHS

IRWIN C. DIETZE, Chairman.
Dept. of Water & Power,
City of Los Angeles, Cal.

TP-16A Stray Railway Current Electrolysis. M. D. Fletcher, Chairman, Illinois Bell Telephone Co., 212 West Randolph St., Chicago 6, Ill.

TP-16B Corrosion of Lead and Other Metallic Sheaths. B. B. Reinitz, Chairman, The Okonite-Callender Cable Co., Inc., 73 Twenty-first St., Paterson, N. J. T. J. Mahland, Co-chairman, American Telephone & Telegraph Co., 32 Sixth Ave., New York 13, N. Y.

TP-16C Cathodic Protection of Cable Sheaths. R. M. Lowall, chairman, American Telephone & Telegraph Co., 1538 Union Commerce Bldg., Cleveland 14, Ohio. W. J. Schreiner, Co-chairman, Cincinnati Gas & Electric Co., Cincinnati 2, Ohio.

TP-16D Tests and Surveys. L. J. Gorman, Chairman, Robin Beach Engineers Associated, 32 Court St., Brooklyn 2, N. Y. Frank E. Kulman, Co-chairman, Consolidated Edison Co. of New York, 4 Irving Place, New York 3, N. Y.

TP-5C Sub-Surface Corrosion by Alkaline Solutions (Caustic Embrittlement). C. F. Pagacar, chairman; Atlantic Refining Co., 260 South Broad St., Philadelphia, Pa.

TP-5F Corrosion by Chlorine. R. I. Zimmerer, chairman; Westvaco Chemical Division, Food Machinery & Chemical Corp., Drawer 8127, Charleston 3, West Virginia.

TP-5G Corrosion by Nitric Acid. J. L. English, chairman; Oak Ridge National Laboratory, P. O. Box P, Oak Ridge, Tenn.

TP-6 PROTECTIVE COATINGS

KENNETH TATOR, Chairman
Consulting Engineer, Montour St.
Extension, Coraopolis, Pa.

PACIFIC (West Coast Div.)
L. L. Whiteneck, Chairman
Long Beach Harbor Dept.
Long Beach 7, Cal.

TP-6A Organic Coatings and Linings for Resistance to Chemical Corrosion. Kenneth Tator, Chairman.

TP-6B Protective Coatings for Resistance to Atmospheric Corrosion. G. G. Sward, chairman; National Paint, Varnish & Lacquer, 1500 Rhode Island Ave., N.W., Washington, D. C. L. L. Sling, vice-chairman; Sline Industrial Painters, 2612 Gulf Terminal Drive, Houston 23, Texas.

TP-6C Protective Coatings for Resistance to Marine Corrosion. Raymond P. Devaluy, Chairman. C. A. Woolsey Paint & Color Co., 229 E. 42nd St., New York 17, N. Y.

TP-6E Protective Coatings in Petroleum Production. Jack P. Barrett, Stanolind Oil and Gas Company, Tulsa, Okla.

TP-6G Surface Preparation for Organic Coatings. A. J. Liebman, chairman; Dravo Corp., Dravo Bldg., Pittsburgh 22, Pa. L. R. Whiting, Bakelite Corp., 30 East 42nd St., New York 17, N. Y.

TP-6H Glass Linings and Vitreous Enamel. G. H. McIntyre, Chairman. Ferro-Enamel Corp., Harvard & 56th St., Cleveland 5, Ohio.

TP-6K Corrosion Resistant Construction with Masonry and Allied Materials. Robert R. Pierce, Chairman, Pennsylvania Salt Manufacturing Co., 1000 Widener Bldg., Philadelphia, Pa.

TP-7 MATERIALS FOR USE AT HIGH TEMPERATURES

M. A. SCHEIL, Chairman
Director Metallurgical Research
A. O. Smith, Corporation
Milwaukee, Wisconsin

TP-8 CORROSION BY WATERS

V. V. KENDALL, Chairman
National Tube Company, Frick
Building, Pittsburgh 30, Pennsylvania

TECHNICAL PRACTICES COMMITTEES' DIRECTORY

(Continued from Page viii)

TP-16E *Corrosion and Protection of Pipe-Type Cables.* Frank Kahn, Chairman, Philadelphia Electric Co., 2301 Market St., Philadelphia 3, Pa.

TP-16F *Nonmetallic Sheath Coatings.* Geo. H. Hunt, Chairman, Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.

TP-17 **STANDARDIZATION OF PROCEDURES FOR MEASURING PIPE COATING CONDUCTANCE**

W. E. HUDDLESTON, Chairman
Huddleston Engineering Co.
Bartlesville, Okla.

TP-18 **INTERNAL CORROSION OF FACILITIES FOR STORAGE AND TRANSPORTATION OF PETROLEUM**

L. G. SHARPE, Chairman
Humble Pipe Line Co.
Houston, Texas

TP-18A *Internal Sour Crude Corrosion of Pipe Lines and Tanks.* R. L. Bullock, chairman; Interstate Oil Pipe Line Co., Box 1107, Shreveport, La. J. M. Hunter, Jr., vice-chairman; Service Pipe Line Co., Box 1979, Tulsa, Okla.

TP-18B *Internal Corrosion of Products Pipe Lines.* Ivy M. Parker, chairman; Plantation Pipe Line Co., Box 423, Bremen, Ga. Raymond Hadley, vice-chairman; Susquehanna Pipe Line Co., 1608 Walnut, Philadelphia 3, Pa.

TP-19 **CORROSION BY DE-ICING SALTS**

F. E. KULMAN, Chairman
Consolidated Edison Company of N. Y., Inc.
4 Irving Place
New York City

Lapel Pins



Approx.
Size

Approximately 7/16 inches high, gold, inlaid with bright red enamel background to "NACE" and deep blue enamel background to words "CORROSION CONTROL." Ruby center.

For Association Members Only

\$7

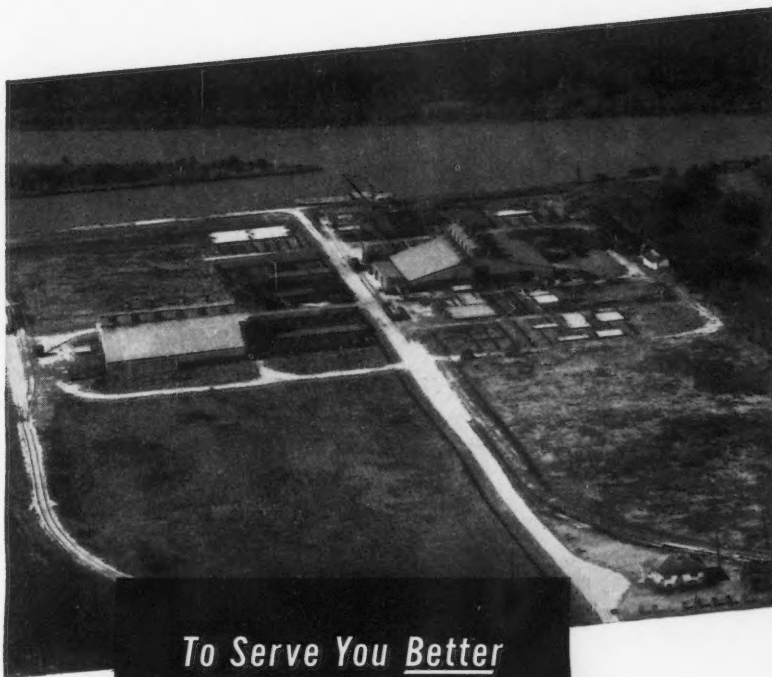
Address Orders to

A. B. Campbell, Executive Secretary

**NATIONAL ASSOCIATION OF
CORROSION ENGINEERS**

1061 M & M Bldg., Houston 2, Texas

BARGE FACILITIES at PLS-Harvey, La.



*To Serve You Better
in the Gulf Coast Area*

Located on the Intra-Coastal Canal across the Mississippi River from New Orleans, the modern PLS plant at Harvey provides most complete facilities for handling shipments by water, as well as by rail and truck. Thus, pipe can be shipped direct from the tube mills—cleaned, primed, coated and wrapped—and then re-shipped by barge, rail or truck to points on the Gulf Coast or overseas.



*It's another plus in
PLS service.*

**PIPE LINE SERVICE
CORPORATION**

Pioneers in Steel Pipe Protection

General Offices and Plant: Franklin Park, Illinois

Plants at Glenwillard, Penna.; Longview, Texas; Corpus Christi, Texas; Harvey, La.; Sparrows Point, Md.

SOMASTIC★

...**"ONLY 20 years old,
but what a record!"**

20 YEARS is a long time on the job, preventing corrosion damage to underground pipe. SOMASTIC Pipe Coating has furnished complete protection at severely corrosive locations since its first year—1930.

In fact, our knowledge of its useful life is limited only by the total time it has been in existence.



SOMASTIC IS The Best PIPE COATING

2 ECONOMICAL METHODS OF APPLICATION:

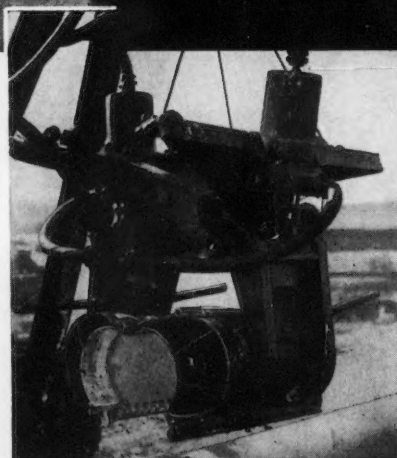
... by Central Plant

... by portable Railhead Plant



RAILHEAD PLANT. Choice between railhead and central plant depends on the economics of a specific job.

HYDRAULIC FORM. Field joints make SOMASTIC protection continuous along the entire coated line.



SOMASTIC PIPE COATING

*Reg. U. S. Patent Office

The sure protection of impervious asphalt-mastic—won't distort under soil stresses; resists shock; prevents electrolysis. Ductile; inert; firmly bonded to pipe.

Inquiries invited

H. C. PRICE CO.

BARTLESVILLE, OKLAHOMA
PHILADELPHIA, PA.
NEW ORLEANS, LA.

*In the 37 States East of
the Rocky Mountains*

BECHTEL CORPORATION

SAN FRANCISCO and
WILMINGTON, CALIFORNIA

*In the 11 Western States
and in Foreign Countries*



with **NATIONAL** Graphite Ground Anodes

TRADE-MARK

SILENTLY and unseen, corrosion has laid waste *billions of dollars worth* of underground and submarine structure in the past year. The most efficient means of preventing such damage is cathodic protection, using graphite anodes.

A properly designed system of impressed-current anodes, utilizing strategically placed "National" graphite ground rods, will not only *retard* corrosion but will entirely *eliminate* it.

Only such a system provides:

Controlled protection to match changing conditions of soil and weather.

Long life and **sustained** efficiency without attention.

Complete **dependability** at low overall cost.

Standard grades in sizes designed to meet specific needs are available in stock for immediate delivery. Consult one of the many reliable engineering firms specializing in corrosion prevention... or write direct to NATIONAL CARBON COMPANY for suggestions on how to overcome your particular corrosion problem.

Send for Catalog Section S-6510

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

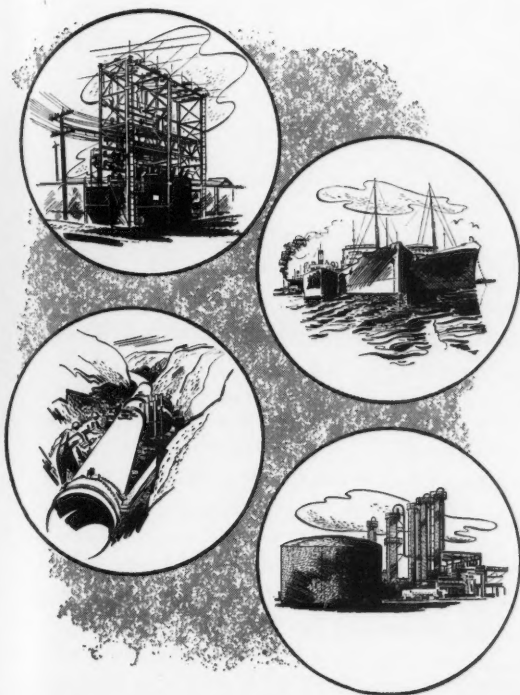
NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

IN CANADA: National Carbon Limited, Montreal, Toronto, Winnipeg



OTHER NATIONAL CARBON PRODUCTS

HEAT EXCHANGERS • PUMPS • VALVES • PIPING • TOWERS • TOWER PACKING • SULPHURIC ACID CUTTERS
HYDROCHLORIC ACID ABSORBERS • STRUCTURAL CARBON • BUBBLE CAPS • BRICK • GRAPHITE ANODES • BRUSHES

Get the facts at
our Calgon booth—
1953 NACE Conference
in Chicago!

threshold treatment* with

CALGON**

controls

corrosion in water systems



calgon, inc.

A SUBSIDIARY OF HAGAN CORPORATION

HAGAN BUILDING
PITTSBURGH 30, PA.

That's right—Calgon protects all types of industrial cooling water systems. A protective film is formed on metallic surfaces by Threshold Treatment with Calgon.

This Calgon film ends corrosion problems in pipes, tubes, and on heat transfer surfaces. Calgon also prevents the deposition of calcium carbonate scale on these surfaces.

Our engineers will be glad to discuss your problems with you, and to show you what Threshold Treatment with Calgon can do for you. For full information, write, wire or call us. And send for your free copy of our booklet "Calgon Controls Corrosion."

*Threshold Treatment with Calgon for controlling corrosion licensed under U. S. Patent 2,337,856.

**T.M. Reg. U.S. Pat. Off.

RIGHT AT THE BEGINNING--



plan to protect your pipe line against corrosion!
...include Bitumastic® Enamel in your original planning

ANY pipe line, whether large or small, is a big investment—an investment that should be properly protected.

That's why it's wise, when planning a new pipe line, to include Bitumastic Enamel in your design plans and specifications. Bitumastic Enamels, manufactured from selected coal-tar, have proved they can prevent corrosion. Many oil and gas pipe lines, laid 20 and 30 years ago, are still giving good service today, thanks to these durable Enamels.

Why not let your Koppers representative work with you from original planning through to final operations? He will be glad to assist you to get the most out of your protection dollar by giving you complete details and estimates.



KOPPERS COMPANY, INC., Tar Products Division, Dept. 204-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



Officers, 1952-53

<i>President</i>	M. G. FONTANA Columbus, Ohio
<i>Vice-President</i>	WALTER F. ROGERS Houston, Texas
<i>Treasurer</i>	R. A. BRANNON Houston, Texas
<i>Executive Secretary</i>	A. B. CAMPBELL 1061 M & M Building, Houston 2, Texas

Directors

President

M. G. FONTANA.....1952-53
Ohio State University, Columbus

Vice-President

WALTER F. ROGERS.....1952-53
Gulf Oil Corporation, Houston, Texas

Treasurer

R. A. BRANNON.....1952-53
Humble Pipe Line Company, Houston, Texas

Past President

N. E. BERRY.....1952-53
Serval Inc., Evansville, Ind.

Representing Active Membership

NORMAN HACKERMAN1952-53
University of Texas, Austin

L. A. HUGO.....1951-54
Phillips Petroleum Co., Bartlesville, Okla.

S. D. DAY.....1950-53
S. D. Day Company, Houston, Texas

AARON WACHTER1950-53
Shell Development Co., Emeryville, Cal.

Representing Corporate Membership

H. P. GODARD.....1952-55
Aluminium Laboratories, Ltd., Kingston, Ont.

V. V. KENDALL.....1952-55
United States Steel Company, Pittsburgh, Pa.

II. A. HUMBLE.....1951-54
Dow Chemical Corp., Midland, Mich.

C. P. LARRABEE.....1951-54
United States Steel Co., Vandergrift, Pa.

V. V. MALCOM.....1950-53
The Philip Carey Mfg. Co., Cincinnati, Ohio

Representing Regional Divisions

L. B. DONOVAN.....(North East) 1951-54
Consolidated Edison Co. of N. Y., New York City

FRANK L. WHITNEY, JR.. (North Central) 1950-53
Monsanto Chemical Co., St. Louis, Mo.

E. D. MCCAULEY.....(South East) 1952-54
American Cast Iron Pipe Co., Birmingham, Ala.

T. F. P. KELLY.....(South Central) 1950-53
James E. Mavor Co., Houston, Texas

L. I. WHITENECK.....(Western) 1952-55
Board of Harbor Commissioners, Long Beach, California.

Directors Ex Officio

E. P. NOPPEL, Chairman Policy and Planning
Committee
Ebasco Services, Inc., New York, N. Y.

TED S. ZAJAC, Chairman Technical Practices
Committee
Shell Oil Company, New York, N. Y.

R. B. HOXENG, Chairman Publication Committee
United States Steel Company, Pittsburgh, Pa.

L. A. BALDWIN, Chairman Regional Management
Committee
Johns-Manville Sales Corp., New York, N. Y.

A Short Cut for Corrosion Researchers

CORROSION researchers making a first step in the solution of a corrosion problem look to the literature to review the experience of others and to weigh others' solutions. Since no man can read everything written about corrosion today, much less catalog in his mind what has been written in the past, some means of selecting only the immediately pertinent material must be devised. Furthermore, the nature of corrosion processes, crossing as they do the physical, chemical and even the atomical sciences, so complicate the problem of selection that even if all pertinent references are available in their several compilations, the physical task of finding them—of tracing them down through indices designed to achieve classifications of material for other purposes—becomes a task too great to even consider, even if the extended time necessary is available.

With this in mind, the National Association of Corrosion Engineers early in its history began consideration of a means whereby this task of selection could be made easier. Several years of discussion ensued, with the outcome that an index was developed useful for classifying published material on corrosion in a way adapted to the researcher's needs.

A system of punch cards was developed to use the index so sorting by several criteria could be accomplished with inexpensive equipment. The facility with which these cards can be sorted reduces substantially the time necessary to select information needed from among the thousands of abstracts of information available. In its first two years of operation the NACE Abstract Card System has issued more than 4200 cards. In January the third year of operation was begun. Constant improvement in indexing is being made and the number of sources from which the abstracts come now exceeds 500.

The National Association of Corrosion Engineers believes it is rendering a real service to industry in making this card service available on a subscription basis and at a very low cost. Most major industrial plants have corrosion problems of sufficient magnitude to justify many times over the cost and the time necessary to maintain this file of abstract cards. An opportunity will be provided for an inspection of a demonstration unit of the card service at the Chicago Conference in March. Corrosion researchers are invited to visit the NACE booth and inspect the cards and get full information about it.

The Corrosion of Domestic Galvanized Hot Water Storage Tanks*

By I. LAIRD NEWELL*

STEEL TANKS for the storage of both hot and cold water are subject to rapid corrosion, unless either the water is treated or the steel surface is given a protective coating. Protective coatings can be divided into two classes, organic and inorganic. The organic coatings are made up of materials such as paints, rubber and synthetic resins, whereas the inorganic coatings are generally composed of glass, enamel or Portland cement. Cathodic protection, such as by externally applied potentials or galvanic coatings, has been used successfully for tank protection when the water is cold, but only the inorganic coatings and cathodic protection have found much favor for hot-water tanks. This paper will be limited to a discussion of galvanized-steel tanks for the storage of hot water.

There appear to be at least three significant factors controlling the corrosion of galvanized-steel, hot-water storage tanks. They are temperature of the water, presence or absence of copper, and types of negative ions present in the water. Various investigators have noted the effect of these factors and some of the more important investigations are cited here.

It was noted as early as 1742 that zinc coatings were protective to iron,¹ and that this protection was due to the galvanic cell, formed when steel surfaces were exposed. Since steel surfaces having continuous zinc coatings are perfectly protected, the life of this surface is of some interest. It depends on the thickness of the coating, the chemical composition of the water, and factors such as temperature, pH and oxygen concentration. According to Anderson,² high-grade rolled zinc has been found to corrode nine times as fast in aerated distilled water at room temperature as in aerated hard water under similar test conditions.

Hydrogen-ion concentration has a wide effect on the corrosion rate of zinc.³ The penetration in inches per year may vary from as much as 0.20 at pH 3.0 to 0.001 at pH 7.0, to < 0.0004 at pH 12.0 and back to 0.20 at pH 14.0.

Galvanized-steel tanks for the storage of hot water in domestic water supplies have been in use for more than 50 years. The excellent results obtained, in many instances, not only with galvanized tanks but with galvanized piping have made the use of galvanized steel quite common. Some installations, made as long as 30 or 40 years ago, are frequently found to be in good condition today. However, with the more prevalent use of copper and brass pipe, connected to

Abstract

After a general discussion of factors which lead to zinc becoming cathodic to steel in hot water tanks the author relates instances pointing to the presence of copper as being a principal agent in the rapid dissolution of zinc protective coatings exposed to heated water. The copper appears to deposit as small metallic particles on the surface of the zinc, forming galvanic cells which lead to rapid pitting. As little as 0.1 ppm copper causes a definite increase in corrosion rate. Examples of six galvanized water tanks in use for periods from 431 to 667 days are given. The author concludes lower corrosion rates can be secured by using all-galvanized systems, by removing carbon dioxide, by removing copper from water or lowering operating temperature to prevent potential reversal. Discussion relates case histories tending to place blame for rapid corrosion in galvanized water heaters on copper piping.

galvanized, hot-water storage tanks, and with the tendency to keep the stored water at higher temperatures, it has been found that with some water supplies galvanized tanks will have extremely short life.

During the past 20 years, it has become apparent that zinc, under certain conditions, will fail to give adequate protection to steel. Of the three factors previously mentioned, the temperature and composition of the water appear to control the electrochemical behavior of the zinc-iron system and, under certain conditions, cause failure of the zinc as a protective agent.

Schikorr⁴ appears to be the first investigator to show that, under certain conditions, zinc could become cathodic to steel and thus actually accelerate the corrosion of the steel, rather than protect it. As a result of his investigation, he found that, if the temperature of the water in galvanized pipes is 120 degrees F or below and if no large amount of air is present, then the zinc does not become ennobled sufficiently to produce a couple with any exposed iron, to cause the iron to act as a soluble electrode. However, with water temperatures as high as 160 degrees F, the zinc becomes more noble than the iron and relatively rapid corrosion of the iron pipe takes place.

G. L. Cox⁵ found that, when zinc specimens were immersed in aerated distilled water for some days at various temperatures, a maximum in corrosion rate was found at about 140 degrees F. Cox believes this to be due to the amount of oxygen available at various temperatures and also to the difference in corrosion product, formed at various temperatures.

Maconachie⁶ confirmed the work of Cox, showing that a maximum corrosion of zinc occurred at a temperature of around 140 degrees F.

Kenworthy and Smith⁷ found in their work that zinc would not protect steel, where the steel was ex-

* Reprinted from *J. of the New England Water Works Assoc.*, 65, No. 1, 71-87 (1951) Mar. Read April 20, 1950.

* Research Chemist, Henry Souther Engineering Co., 11 Laurel St., Hartford, Conn.

posed to certain solutions, when heated to 185 degrees F. They believed that, in order to have satisfactory life for galvanized steel, the carbon dioxide should be less than 5 ppm and there should be a total hardness of more than 100 ppm.

Bonilla⁸ found that galvanized pipes carrying hot water showed pitting which was more severe than obtained with ungalvanized iron pipes. He also found that the zinc coating on these pipes remained after 15 years and believed this to show that the zinc coating was cathodic to the steel.

Gilbert⁹ studied the effect of water composition and temperature on the electrochemical behavior and corrosion of zinc-iron couples. He found that zinc can become cathodic with respect to steel in both distilled and hard water. A temperature of 140 degrees F is necessary, but when the zinc has become cathodic, the temperature may be lowered to some extent without reversal. Since the chief reaction occurring in neutral solutions in the corrosion of zinc is oxygen absorption, the presence of dissolved oxygen is necessary for zinc to become cathodic. Where the zinc coating is one produced by hot galvanizing, a zinc-iron alloy layer is formed, which becomes cathodic to steel in aerated water, whether hot or cold, and is more cathodic than zinc under similar conditions. Thus, corrosion of the galvanized layer may stop when the zinc-iron alloy is reached. However, pitting can occur and usually penetrates into the steel.

Hoxeng and Prutton¹⁰ also investigated the effect of chemical composition of the water and water temperature. They confirmed the work of Gilbert that zinc may become cathodic to steel under certain conditions. They found that chloride and sulfate ions decreased the probability of reversal of the zinc-steel couple, while bicarbonates and nitrates promoted such reversal. Increasing temperature increases the probability of reversal, but depends on electrolyte composition.

Figure 1 shows graphically the effect of the bicarbonate ion on the potential of zinc, when measured against a saturated calomel electrode. The fact that steel has a potential of -0.6 to -0.7 volts against a calomel electrode indicates the zinc to be cathodic to steel under these conditions.

The results obtained by these investigators show that, in order for galvanized steel to have satisfactory life in hot-water storage tanks, the temperature of the water should be maintained below 140 degrees F. It would also be desirable to have a minimum concentration of bicarbonate and nitrate ions and a substantial quantity of sulfate and chloride ions.

Another factor influencing the life of galvanized-steel water-storage tanks is the presence of traces of copper in the water entering the system. The increased use of copper and copper alloys for piping, fittings and valves of domestic water systems has had a marked effect on the life of galvanized tanks.

McKee¹¹ has found that a concentration of 1 ppm of copper sulfate in a cooling system caused the removal of the galvanizing from pipes in as short a time as two months.

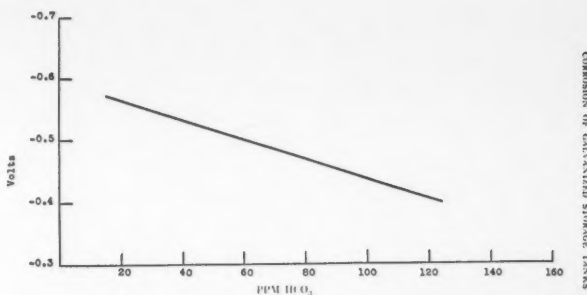


Figure 1—Effect of bicarbonate concentration on zinc potential. Time, 6 hours. Temperature, 140 degrees F. Solution, SO_2 , 10 ppm, NO_2 , 5 ppm. (No salts added to distilled water.) From data by Hoxeng and Prutton.

Kenworthy,¹² who studied the problem of copper and galvanized iron in the same water system, concluded that the rate of corrosion of galvanized iron or zinc is materially increased by the presence of traces of copper in water. As little as 0.1 ppm of copper causes a definite increase in corrosion rate. With amounts of copper up to about 0.3 ppm, the degree of corrosion is proportional to the amount of copper, but with copper concentration of 10 ppm, the corrosion rate is less than proportional. The copper appears to deposit as small metallic particles on the surface of the zinc. Galvanic cells then form, with the copper particles as cathodes and the zinc surface as the anode. With many natural waters, sufficient copper is dissolved, by the simple passage of water through copper pipes, to affect the rate of corrosion of galvanizing, but not sufficient to have a noticeable loss from the copper pipe. The amount of copper dissolved by a water will depend on the composition of both pipe and water. Increased carbon dioxide will increase the copper dissolved and it is suggested that the free carbon dioxide be limited to 2 ppm.

The author has made a study of seven galvanized, domestic water-storage tanks, which have been in service for periods ranging from 431 to 667 days. Six of these tanks were equipped with single magnesium rods to give additional cathodic protection. The magnesium rods were not centered on the axis of the tank, but were offset as much as several inches. The magnesium rod in the seventh tank became disconnected from the tank after a few days and it is believed that the rod had no effect on the corrosion of the tank. These tanks were operating in a soft water at temperatures from 165 degrees F to 170 degrees F, the water having the analysis shown in Table I.

TABLE I—Water Analysis

pH	6.6
Conductivity (mhos)	60
Alkalinity	6 ppm
Total Hardness	17 ppm
Fixed Solids	30 ppm
Chlorides	2.8 ppm
Free Carbon Dioxide	3 ppm

The tanks were connected to piping systems having copper or copper alloys in some part of the influent piping. All of these tanks showed severe pitting-type corrosion, as shown in Figures 2 and 3. It was also noted that the tubercle density was higher on those areas of the tanks farthest from the magnesium rod.

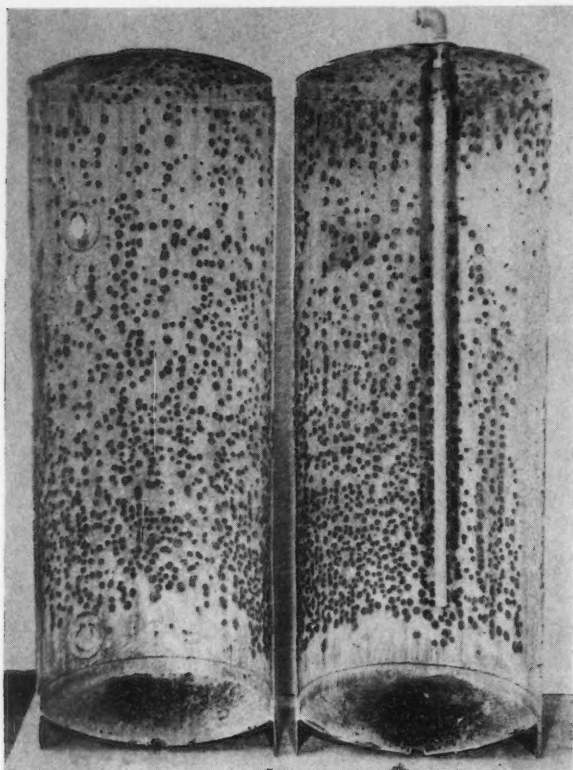


Figure 2—Tank capacity 52 gal.; service 432 days; pit depth 0.023-inch max. Magnesium rod connected.

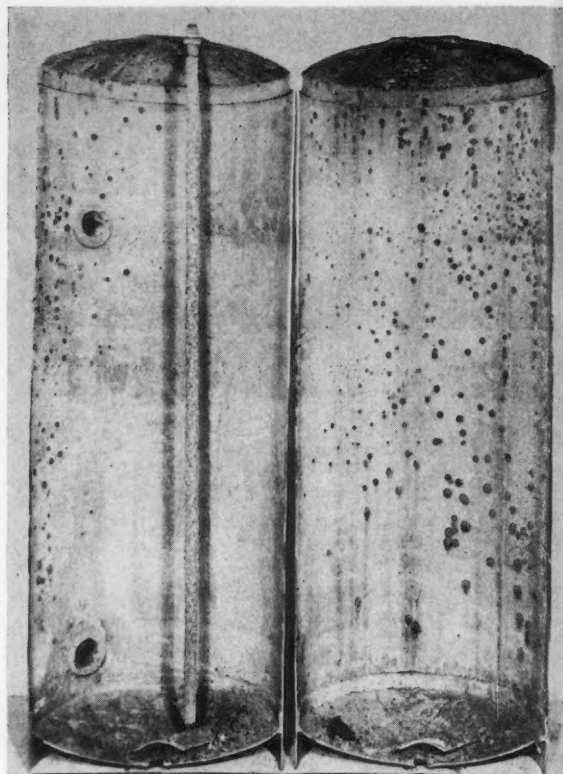


Figure 3—Tank capacity 52 gal.; service 450 days; pit depth 0.026 max. Magnesium rod connected.

This indicates some protection by the use of the magnesium anode.

Pit depths were measured with an inside micrometer, after cleaning off the tubercle with a revolving bristle brush. It was noted that most of the tubercles and pits were characterized by the presence of a hard disc over the center of the pit. The pits showed depths ranging from 0.009 to 0.075 inch. This disc was shown to contain significant amounts of copper. Figures 4 and 5 show photographs of typical corrosion pits found in these tanks, while Figure 6 shows a sketch of a tubercle having a copper-containing disc.

Microscopic examination of a section through the corroding galvanized layer showed interlamellar corrosion of the zinc-iron alloy. Figure 7 represents a photomicrograph of the galvanized layer and shows corrosion extending through the zinc layer.

As a result of these tests, the predicted life of these tanks was less than five years, with the probability that any individual tank would not have a life exceeding seven years before failure by leakage would occur. It is quite likely that difficulties due to "red water" would occur somewhat earlier than the failures by leakage.

Our study has shown that severe corrosion may be experienced in galvanized, domestic, hot-water storage tanks, using a soft water.

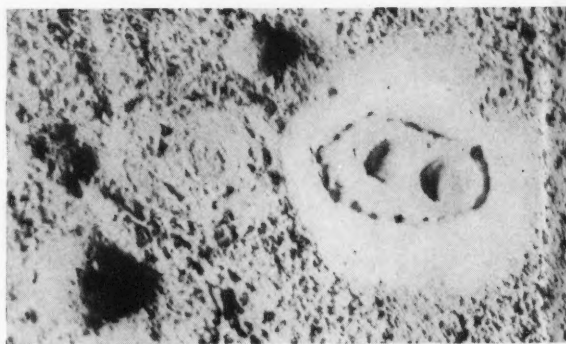


Figure 4—Twin pits under a single tubercle, the pits having diameter of approximately $\frac{1}{4}$ -inch.

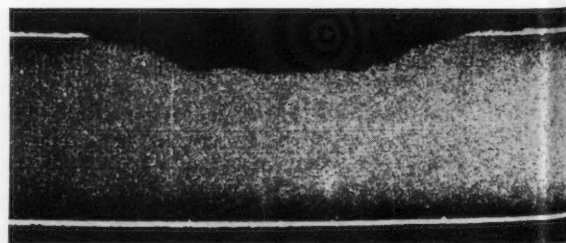


Figure 5—Photomicrograph of a section through a typical pit from which the corrosion product has been removed. This section shows total thickness of the steel shell and the galvanizing, both interior and exterior. Magnification 10X; etch, 1 percent Nital.

KENN
been of
respects
more al
tanks, b
costs. T
years f
question
tanks h
a water
Lengt
ance, w
of mate
tion of
vanized
over cop
the per

Increased corrosion and lower tank life are believed due to:

- 1) the presence of traces of copper in the water supplied to the tanks;
- 2) operating temperatures in excess of 140 degrees F, which tend to cause potential reversal in the zinc-iron galvanic couple;
- 3) the presence of significant amounts of bicarbonate and/or nitrates in the influent water.

Lower corrosion, with consequent longer tank life, may be expected when:

- 1) Systems are all galvanized, with no copper.
- 2) Pipe is of a resistant copper alloy, such as aluminum brass.
- 3) Water is aerated, to remove carbon dioxide.
- 4) Water is treated with lime, to react with carbon dioxide.
- 5) Copper is removed from water by passing through zinc.
- 6) Operating temperature is lowered, to prevent potential reversal.
- 7) Magnesium rod is provided in waters having sufficient conductivity.

The author wishes to thank Mr. A. L. Bisbee of the Hartford Electric Light Co., Hartford, Conn., for permission to reproduce many of the illustrations used in this paper.

Bibliography

1. R. H. Brown and R. B. Mears. *Trans. Electrochem. Soc.* (1942).
2. E. A. Anderson. Symposium on "Cathodic Protection," Nat. Assoc. Corrosion Eng. (1949).
3. B. E. Roetheli, et al. *Metals and Alloys*, 3, 73 (1932).
4. G. Schikorr. *Gas u. Wasserfach*; also *Trans. Electrochem. Soc.*, 66, 212 (1939).
5. G. L. Cox. *Ind. Eng. Chem.*, 23, 902 (1931).
6. J. E. Maconachie. *Trans. Electrochem. Soc.*, 66, 212 (1934).
7. L. Kenworthy and M. D. Smith. *J. Inst. Met.*, 70, 463 (1944).
8. C. F. Bonilla. *Trans. Electrochem. Soc.*, 87, 237 (1945).
9. P. T. Gilbert. Pittsburgh International Conference on Surface Reactions (1948).
10. R. B. Hoxeng and C. F. Prutton. *Corrosion*, 5, 330-338 (1949).
11. C. C. McKee. *Power Plant Eng.*, 36, 658 (1932).
12. L. Kenworthy. *Jour. Inst. Metals*, 69 (Part II), 67 (1943).

Discussion

KENNETH F. KNOWLTON*.—Mr. Newell's paper has been of great interest to me, particularly in two respects. The first is the fact that we must know more about the life expectancy of hot-water storage tanks, built of various materials of widely divergent costs. The second reason is that during the past two years four specific instances of unsatisfactory or questionable performance of galvanized hot-water tanks have been brought to my direct attention as a water-supply chemist.

Length of expected service and quality of performance, weighed against cost, usually govern the choice of material for hot-water storage tanks. Examination of Table I shows that the best tanks of galvanized iron enjoy a tremendous price advantage over copper, the most common competitor. Of course, the percentage advantage is less when a complete,

* Superintendent-Chemist, Salem and Beverly Water Supply Board, Filtration Plant, North Beverly, Mass.

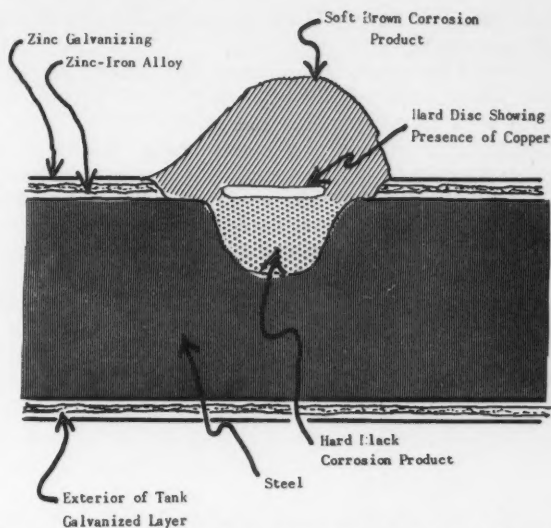


Figure 6—Sketch of section through tubercle, showing location of copper-containing disc.

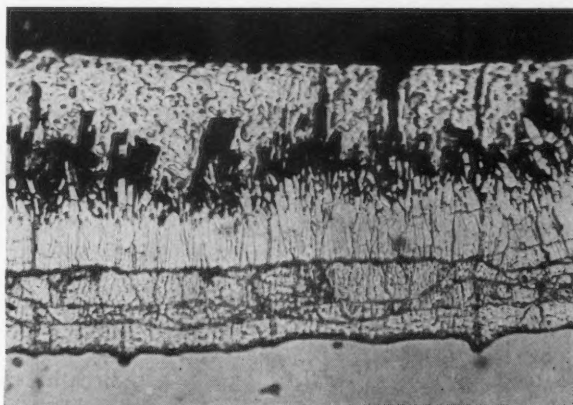


Figure 7—Micrograph of section through galvanized surface near a corrosion pit, showing interlamellar corrosion of the zinc-iron alloy. This photo also shows voids leading to the surface of the zinc layer. Magnification 500X, etch 1 percent Nital.

automatic heating unit is considered, but there are still a great many users of plain storage tanks.

TABLE I—Retail Prices of Hot-Water Storage Units, May, 1950

1. 30-gal. capacity hot-water tanks only:	Retail price
a. Light weight galvanized.....	\$ 21.00
b. Medium weight galvanized.....	24.00
c. Double extra heavy (300-lb. test) galv.....	28.00
d. Copper, 250-lb. test.....	82.35
e. Copper, 350-lb. test.....	105.00
2. Automatic water-heating units, 30-gal. capacity, gas-fired:	
a. With galvanized-iron tank.....	\$110.00
b. With monel or copper tank.....	175.00

The history of the four individual cases of severe trouble with galvanized hot-water tanks will be given individually, since Mr. Newell's description of the action of copper seems in large measure to explain at least three of the cases.

Case No. 1.

This was a 40-gal. tank, approximately six months old, connected to a heat exchanger on a household

steam-heating boiler. The circulating pipe was partly of brass and partly of copper.

At roughly two-week intervals, the circulating pipe near the hot side of the exchanger would become so filled with sludge that it required flushing to restore circulation. Analysis of the wet sludge is shown in Table II. Active corrosion was obviously present in the system and the dissolved corrosion products were apparently being precipitated by the heat. Upon further investigation, the owner stated that he had used the copper drop pipe from his old copper tank to convey the cold incoming water through his new galvanized tank.

It was recommended that he remove this copper tube and make the cold-water connection at a plug near the bottom of the tank and, if he wished to gain advantage of the remaining depth at the bottom, to use a short piece of tinned pipe inside the tank at this point.

This change was made and six weeks later the owner called to say that his trouble had been eliminated.

TABLE II—Analysis of Wet Sludge from Circulating Pipe to Hot-Water Tank in Case No. 1

	Ppm.
Iron (Fe)	1560
Copper (Cu)	22.4
Zinc (Zn)	320
Phosphate (PO ₄), unfiltered	24.1
Phosphate (PO ₄), filtered	0.80
pH	7.2

Case No. 2.

This tank was an integral part of one of the better makes of automatic, oil-fired hot-water units, having a galvanized tank with a central flue.

At the time I was called in, the unit was approximately two years old and had started giving trouble, because of rusty water, almost immediately after its installation. In this case, the water temperature had been high—about 160 degrees to 180 degrees. Analysis of the material flushed from the bottom is given in Table III and shows high iron and zinc content. So far as is known, the tank had not been previously flushed out.

The jobber who installed the unit flushed the tank thoroughly at this time and installed a magnesium anode, in an effort to control the corrosion.

Two months later the tank was still giving trouble and it was suggested that the cold-water drop pipe inside the tank might be of copper. The jobber was shown a laboratory experiment, with a brass-iron couple in one beaker and iron only in another beaker, which definitely showed the difference in corrosion rates when the two beakers were heated. Immediately the jobber checked the tank and found the suspicion to be fact. The case this time was closed by the jobber's installing a new tank, rather than inconvenience his customer any further.

Of about a dozen identical, or supposedly identical, units sold by this dealer this was the only one to give trouble. Recently the writer obtained this discarded tank and had it split open. The tank is covered with large pits, especially on the central tube, which was hottest, while the area between the pits

is still coated with zinc in sufficient thickness to take off chips with a chisel and then to verify the zinc in the laboratory.

TABLE III—Analysis of Sludge in Bottom of Water Tank in Case No. 2

	Ppm
Iron (Fe)	20,400
Zinc (Zn)	8,750
Magnesium	absent
Phosphate (PO ₄)	nil
Insoluble material	904
pH	6.8

Case No. 3.

This is a unit of the same make as No. 2, but gas-fired and installed by a different jobber in a new house, otherwise completely plumbed with copper. Red water caused several calls to the Water Department to have the street main flushed and in each instance the street main was found to be clean.

Finally the owner was told that the tank probably has a copper tube inside that was causing the trouble.

In this case our contact was with the owner, and he has had no success in getting an adjustment or study from the department store which sold and installed the unit. The only comment from the store was that the water was at fault. At the time of preparing this discussion the unit was still giving trouble and no steps had been taken to correct it.

Case No. 4.

This case covers a group of gas-fired galvanized hot-water heaters in a new veterans' housing project. All piping, including service lines, was of copper tube. We were called at a time when these units were between two and four months old, the complaint arising from a report of turbid, not red or colored, water to the housing authority. Their man had drawn one pint of water from the bottom of a tank and, upon straining it through a clean handkerchief, obtained a cake about 1/8 inch thick of material that looked like gray clay.

Only one occupant in the development had noticed the turbidity at the tap, but all the tanks contained a similar material. Analysis showed the material to consist primarily of zinc hydroxide, zinc phosphate and zinc carbonate.

From this experience we concluded that the zinc normally was removed very rapidly from the inside of the tanks and that, due to its light color, it was not noticed in the hot water until the iron began to corrode and the entire flocculent mass became red in color. Further samples from other miscellaneous tanks seemed to bear this out. Tanks with large amounts of "rusty" sediment, which had not been flushed, were found to have more zinc than iron in the sediment, and those which had been flushed out thoroughly developed only a relatively small volume of sediment, which was mostly iron.

Mr. Newell's observations on the accumulation of copper on the zinc surfaces are very interesting. We have not tried to make any similar tests, but on a few occasions have checked the copper content of water from various taps.

In particular, we have a sampling tap at the filtra

tion p
50 ft.
the fir
after t
the w
In
troubl
operat
six ye
case th
of gal
supply
follow

THE
Sta
of direc
tions.¹
each ye
a porti
method
Howev
large th
in many
In co
tection,
parts: I
in a par
part of
cathodic
actual c
factors
readily
protecti
terms of
In or
calculat
uniform
is the r
finds its
line an
studies
principle
plicable

Deter

* Presenta
mer Meel
Engineer

tion plant, which is on a $\frac{1}{2}$ -inch copper tube about 50 ft. long. Recent samples from this tap showed the first quart to contain 0.8 ppm of copper and, after thorough flushing of several minutes' duration, the water still had a copper content of 0.2 ppm.

In contrast to the reported instances above of troublesome units, I might state that one of our operators has an oil-fired, galvanized hot-water unit six years old, which has given no trouble. In this case the service pipe and all piping to the unit are of galvanized iron. In all of these cases the water supply is the same. Its approximate analysis is as follows:

Carbon dioxide	3 ppm
pH	6.9
Total alkalinity	16 ppm
Sulphate	25 ppm
Hardness (soap)	45 ppm
Calgon	1.0 ppm

It is my opinion that more studies in the nature of those made by Mr. Newell would be well worth while and that the results of the studies should be made generally available to the manufacturers of these products, and particularly to the plumbing industry.

I wish to express my thanks to the personnel of the Water Laboratory of the Massachusetts Department of Public Health for making the quantitative analyses of sludges used in these studies.

Economic Aspects of Cathodic Protection*

By RAY M. WAINWRIGHT

Introduction

THE CORROSION BILL for metals in the United States amounts to more than $5\frac{1}{2}$ billion dollars of direct costs each year, according to recent calculations.¹ Enough steel reverts to non-useful oxides each year to build a fleet of battleships. Perhaps only a portion of this steel could be saved by modern methods of cathodic protection corrosion control. However, the salvable portion is still sufficiently large that cathodic protection becomes a major factor in many calculations involving engineering economy.

In considering economic aspects of cathodic protection, the problem can be divided into three distinct parts: First, a determination of the cost of corrosion in a particular situation; second, an analysis of what part of these corrosion losses could be prevented by cathodic protection; and third, an evaluation of the actual cathodic protection costs. Knowing these three factors for any given situation, the engineer can readily show the economic feasibility of the cathodic protection installation and the resultant savings in terms of dollars.

In order to arrive at some common method of calculation, it is desirable to reduce costs to some uniform basis and probably the annual cost method is the most useful. Also, since cathodic protection finds its greatest use at present in underground pipeline and cable systems, the following economic studies are drawn primarily from this industry. The principles outlined, however, are in most cases applicable to other industries with slight modifications.

Part I—Corrosion Costs

Determination of the first factor—corrosion costs

*Presented at the Winter General Meeting, and at Portland Summer Meeting, August, 1951, of the American Institute of Electrical Engineers. Submitted for publication May 5, 1952.

RAY M. WAINWRIGHT—Associate professor of electrical engineering at the University of Illinois, Urbana, received his B.S. in E.E. degree from Montana State College and his M.S. degree from the University of Illinois. In 1936 he joined the Montana Power Company as assistant electrical engineer and in 1938 became electrical engineer for Montana-Dakota Utilities Company of Minneapolis working on corrosion and communication problems. In 1945 he became research engineer for that company, after leave during the war to act as research engineer on Signal Corps operations. Since 1946, Professor Wainwright has been on the faculty of the University of Illinois, where he has taught courses in electrical circuit analysis and engineering economics and has headed a research project on criteria for cathodic protection. He is chairman of the AIEE Subcommittee on Cathodic Protection; a member of the Corrosion Committee of the American Gas Association, of TP-16 and TP-19 committees within the NACE, and of numerous other technical organizations. He has done considerable consulting work in cathodic protection in recent years, and has written a number of papers in the corrosion and cathodic protection areas.



—always involves many intangible items, but there are several types of direct costs which are readily apparent in most instances. Consider, for example, a pipeline carrying oil, water or gas as a product. The direct costs may be grouped as follows:

- a) Cost of product lost through leaks
- b) Loss of revenue
- c) Cost of labor and materials to repair the leaks
- d) Damages to landowners for excavations, and, in some cases, for land rendered unfit for use due to product saturation
- e) Cost of overhead, engineering and testing in leak repair program
- f) Increase in annual depreciation charge due to shortened life of pipeline.

One authority has estimated recently¹ that these direct costs as just listed amount to \$600,000,000 a year for the oil, water and gas pipelines within the

Abstract

The corrosion bill for metals in the United States amounts to more than 5½ billions of dollars each year. Cathodic protection measures could eliminate probably over a billion dollars worth of this corrosion. For pipelines, corrosion costs annually from 2 to 5 percent of the original investment. By means of proper coatings and cathodic protection the costs incidental to corrosion can be reduced to from 1 to 2 percent, annually, of the initial investment. Since the initial investments run into the billions of dollars, cathodic protection becomes a significant factor in the engineering economic picture.

A very important item is the possibility of reduction in steel content of pipelines based on modern methods of coating and cathodic protection. Besides the direct savings in operating and maintenance, other indirect savings include conservation of product, continuity of service and public relations improvements.

Annual cost accounting methods are advantageous for analysis of cathodic protection and coating economics. Costs may be reduced to expressions involving cathodic protection and coating requirements, and the optimum combination selected.

Partial protection is also very desirable in many cases involving poorly coated lines and can be justified by reductions in sinking fund deposit factors due to increased pipe life, in addition to the usual savings in operations.

Electrical engineers should anticipate that cathodic protection will effect savings in other corrosion areas. Power plant equipment, cables, substations, docks, ships and other situations involving metals in contact with soils and solutions are fertile fields for the application of cathodic protection and modern techniques of corrosion control.

continental limits of the United States alone. Other examples of direct costs include \$225,000,000 a year to replace corroded domestic hot-water-heater tanks, \$60,000,000 a year to replace boilers and feed water systems, and \$50,000,000 a year in oil refinery maintenance and repair. In all of the above cases cathodic protection offers a definite means of reducing corrosion. If a 60 percent reduction is effected in the above cases only, the potential savings amount to more than \$500,000,000 a year. Certainly, then, this field should be a fertile one for the electrical engineer, upon whose shoulders falls the principal burden of designing and operating the cathodic protection systems.

Direct costs a) through d) above have been estimated by one experienced engineer to average not less than \$300 per leak for the average pipeline.² For oil lines this figure may be higher due to the increased value of the lost product and the more likelihood of extensive damages and less for gas distribution systems and shallow water lines. Cost e) will vary with the organization, but it may easily vary between \$5 and \$25 per mile per year. Cost f) is a major item and warrants a more complete study.

In engineering economic studies it is valid to consider an annual depreciation charge as an annual sinking fund deposit, D_L , which, if invested each year, would accumulate to a sufficient amount, A_L , in some estimated life, L , to replace the pipeline. For example, consider a pipeline which is expected to have a life of, say, ten years in some particularly corrosive soil area. In the ten years the sinking fund deposits must accumulate to an amount equal to the replacement cost

of the line less any salvage value plus the cost of salvage. In many cases the last two amounts are considered to balance each other and the accumulated amount is set equal to the cost of a new line. Now, if by some engineering procedure such as cathodic protection the life is extended to twenty years instead of ten, the sinking fund deposit can be diminished accordingly, and the saving is: $D_8 = D_{10} - D_{20}$ dollars per year. If the engineering procedure extends the life indefinitely, the saving per year becomes the original sinking fund deposit, D_{10} .

This sinking fund deposit reduction or increase is a very important item in corrosion cost analysis. Many engineers tend to compare the cost of renewing or reconditioning a line with the initial cost of cathodic protection, when they should actually compare the reduction in sinking fund deposit with the cathodic protection costs after the latter are reduced to an annual basis. It makes no difference whether the accounting department of the pipeline company is keeping accounts on a sinking fund or a straight line basis; the engineer in making an accurate analysis must base his work on the sinking fund method in all cases, because of the large sums of money involved.

That the reduction is of importance can be shown vividly by an illustration. A good cost figure for a 12-inch high pressure gas line, 300 miles long, would have been around \$7,000,000 in 1950. Assume that the replacement cost will be approximately the same at any time. With reinvestment money at 4 percent compounded annually, the sinking fund deposits for various estimated lives is as follows:

	Per Year
10 year life.....	\$582,000
20 year life.....	234,500
30 year life.....	124,200
40 year life.....	73,500
50 year life.....	45,600
60 year life.....	29,200
100 year life.....	5,600

If the life were assumed to be twenty years without cathodic protection and sixty years with cathodic protection, engineers could afford to spend \$205,300 per year on cathodic protection based on this one item in the direct costs, or 2.86 percent of the original investment.

Figure 1 consists of a group of curves showing the reduction in sinking fund deposit for various values of total life of the pipeline, each curve representing a different original life assumption. The interest rate for reinvestment purposes is again taken as 4 percent compounded annually.

So far only the direct costs of corrosion have been considered. The indirect and intangible costs may be outlined as follows:

- Over design of pipelines as to steel thickness
- Necessity for parallel and duplicate facilities to insure continuity of service, especially near large load centers
- Loss of public good will
- Damage suits arising from gas and oil fires and explosions, or from water damage
- Difficulty in obtaining new financing due to poor condition of assets.

One major gas company has reduced the weight



Figure 1—
pe

per foot
applied
panies
5 per
line, th
Eviden
rosion o
of the
enginee
to comb
to the c
when s
gardless

It is c
above i
definite
Rapidly
executi
service,
percuss
of publ
plosions
compan
history
prospec

Perha
of all o
could be
of the i
tion wer
an estim
larger th

This r
the pipel
annually
ought to
neering
Only in
of Corro

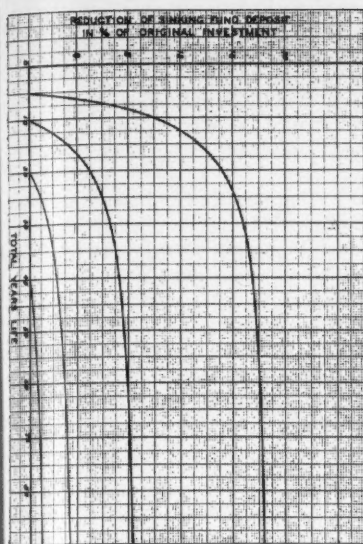


Figure 1—Reduction of sinking fund deposit in percent of original investment.

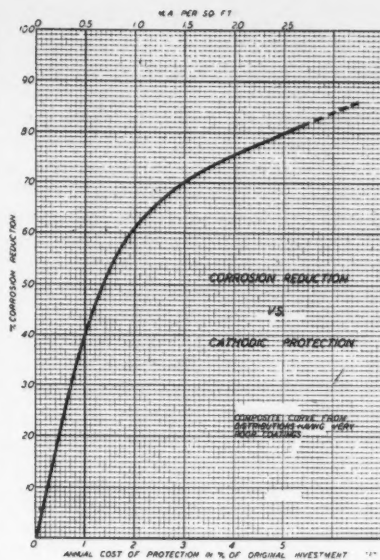


Figure 2—Corrosion reduction vs cathodic protection. Composite curve from distributions having very poor coatings.

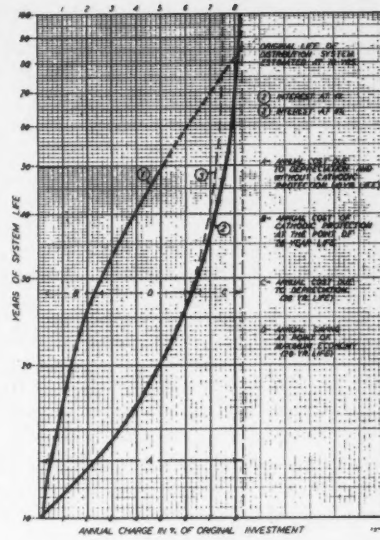


Figure 3—Original life of distribution system estimated at 10 years.

per foot of its pipelines, where cathodic protection is applied, by an average of 20 percent.³ Other companies have made similar reductions ranging from 5 percent to 40 percent. On a 300-mile, 12-inch gas line, this saving could amount to around \$1,000,000. Evidently item a) of the indirect first costs of corrosion can be of an order of magnitude of 20 percent of the original investment. This would indicate that engineers in the past have been adding layers of steel to combat corrosion—certainly not a cheap solution to the corrosion problem, particularly in time of war when steel is vitally needed for other purposes, regardless of its cost.

It is difficult to evaluate items b) through e) of the above indirect costs. However, occasionally these are definitely known to reach significant proportions. Rapidly deteriorating pipelines have caused anxious executives to hasten looping projects; shutting down service to recondition lines has caused political repercussions leading to adverse rate decisions and lack of public support in franchise hearings; gas explosions and fires due to corrosion leaks have cost companies \$50,000 for a single leak and finally, a history of rapidly mounting leaks does not influence prospective bondholders favorably.

Perhaps a rough, but conservative, approximation of all of the indirect costs of corrosion on pipelines could be estimated at 1 percent to 3 percent per year of the initial investment, presuming cathodic protection were not applied to the pipelines. Based on such an estimate, the indirect costs of corrosion may be larger than the direct costs previously outlined.

This result would indicate that corrosion losses in the pipeline industry alone may be over \$1,000,000,000 annually. Without question here is a situation which ought to receive more attention in the way of engineering investigations and university research work. Only in recent years since the National Association of Corrosion Engineers has come into being and has

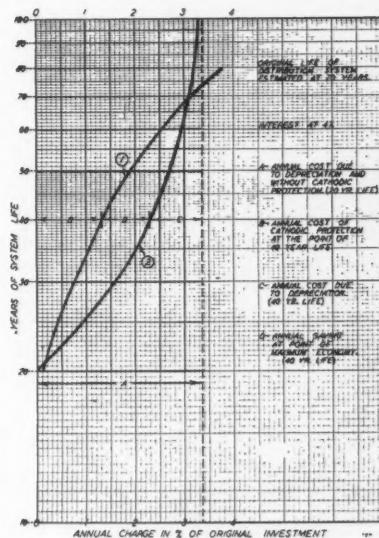


Figure 4—Original life of distribution system estimated at 20 years.

assumed some of the investigational burden, has any concerted attack been made on the overall problem. As yet only a handful of the larger universities have done any work on corrosion mitigation from the cathodic protection standpoint; laboratory work has been confined chiefly to large manufacturers, using organizations and laboratories of the Army, Navy and National Bureau of Standards.

Part II—Benefits of Cathodic Protection

Proof of cathodic protection benefits has come from both the laboratories and from the owners of operating installations. A search of magazine literature for the past fifteen years will show a tremendous number of articles all testifying to the fact that cathodic

protection is a successful means of combating many types of corrosion—the statistical evidence is amply quantitative. The literature is full of cases where pipelines were riddled with leak-holes and were considered ready for reconditioning, yet after the application of cathodic protection, these same pipelines are still operating ten and fifteen years later, with practically no further evidence of deterioration.

However, not all engineers are agreed as to what is a proper and satisfactory criterion for protection. How does one know when the metal surface is protected and what is the degree of protection obtained? The answer, of course, lies in the electro-chemical theory concerning metal-solution interface reactions and phenomena. But an investigation into these phenomena is certainly beyond the scope of the field engineers and even of many laboratories.

The most popular criterion in use among field engineers today is probably the method of observing the potential in volts between the buried or immersed metal surface and the soil or solution at or near the ground level or in the vicinity of the metal structure. This is done by means of a metallic connection to the metal, a high resistance voltmeter (of more than one megohm per volt) and a copper-sulfate half cell contacting the earth or solution by means of a saturated porous plug. When the metal structure shows a voltage of -0.85 volts with respect to the soil or solution, the metal is considered "protected."

An alternative criterion to the pipe-to-soil potential method above described is the frequently-used method of current density. This is usually stated in milliamperes per square foot of metal surface and refers to the current required from an outside source to maintain the voltage of -0.85 per square foot of surface protected. Obviously, this criterion varies with the metal surface environment and is related to the presence of non-metallic coatings, the soil or solution resistivities and many other factors. For bare steel the criterion for "complete" protection usually ranges from 1 to 5 milliamperes per square foot of surface, depending upon the nature of the soil or solution. For metal surfaces well-coated with bituminous enamels or asphaltic compounds, the current requirements are reduced to insulation leakage currents and currents through flaws in the coating and may amount to 0.1 ma or less per square foot.

The curve of Figure 2 shows the estimated average extent of cathodic protection vs. current densities for a group of essentially bare distribution systems. Similar curves could be constructed based on data from metals in different environments. The principal item of significance here is that the cost of achieving cathodic protection is not a linear relation. The cost of 50 percent protection, for example, is usually much less than half the cost of full protection. This is of significance in economic analysis of partial cathodic protection.

Part III—Cost of Cathodic Protection

The cost of cathodic protection on an annual basis

may be studied by the use of the following formula:⁴

$$C = C_f + C_p = C_f + \frac{I_d ADM}{1000}$$

where

C_f = total annual fixed charges in dollars incurred to prepare system for cathodic protection

C_p = the annual cost of cathodic protection power in dollars

I_d = the required current density in ma per sq. ft. for complete protection

A = the surface area in square feet to be protected

D = the current distribution factor

M = the cost in dollars of direct current per ampere year

Knowing the relationships between the potential (metal-to-soil) and the current density as previously discussed, the engineer can fix I_d in ma per sq. ft. Multiplying I_d by $A/1000$ then gives the total current required per unit installation or per unit distance of pipeline in amperes.

D is a factor which, when multiplied by the current required, gives the current which it is necessary to supply per installation or per mile. The presence of D is required since some overprotection may exist due to the geometric relations in the installation. For example, if current is supplied to one point of a section of pipeline, the potential-to-soil must be increased materially at that point so that the end points of the section will not fall below the -0.85 volts. The higher voltages result in greater current densities near the supply point and therefore in wasted current. If D is decreased by multiple installations in the same section, the fixed charges may increase and the final solution usually results in compromise between fixed charges and D . It is obvious that D must be greater than unity and in practice may range from slightly over 1 to 5 or greater.

M is the cost of direct current power per ampere year and when multiplied by the remainder of the factors gives C_p , the annual operating cost of the source of cathodic protection power per unit installation or per unit distance.

Two principal means of supplying the external source of direct current are in common use: a) rectifiers and generators driven from ac power lines, windpower, or internal combustion engines; and b) sacrificial anodes such as aluminum, zinc or magnesium. Of the first classification probably the majority of new installations are of the ac powered selenium rectifier type; and of the second, the modern trend seems to be toward magnesium anodes. The following examples of the use of the above equations for cost are restricted, then, to selenium rectifier and magnesium anode installations.

Magnesium anodes may be installed for around \$15 to \$25 per ampere year as an initial cost, based on a ten year estimated life. If interest is considered as 4 percent, taxes, etc., as 3 percent, and depreciation as 10 percent, M is then 17 percent of the initial cost for ten years, or approximately \$25 to \$42 per ampere year (as of 1950). From an examination of the literature, rectifier installations give an M (in 1950) of from \$10 to \$20 per ampere year depending upon the

cost of the ac power, the number of installations in one group and similar factors.

However, one engineer² reports a D of 3.75 for a typical rectifier case with a D of about 1.00 for the corresponding magnesium anode case, both being designed for 100 percent protection. If the ampere year cost of power were 3.75 times greater in the anode case, the total cost would have been the same for both installations. This analysis shows that the cost of rectifiers and of magnesium anodes may be competitive regardless of the apparent difference in annual cost of delivered power. C_t is considered to be the same in either case, which may not be true. C_t includes annual charges arising from bonding, etc., and is essentially zero for a new line designed for cathodic protection.

The cost of cathodic protection is affected to a large extent by I_a . It has been noted that on bare steel this figure may run from 1 to 5 ma per sq. ft. and yet on coated lines may drop to a small fraction of these values. If K is the equivalent annual cost per square foot of coating the metal with some insulating coating, and C_T is the total annual cost of coating plus cathodic protection, then

$$C_T = KA + C_t + \frac{I_a \text{ADM}}{1000}$$

Now I_a is an inverse function of K in a rather complex manner. Let this function be $f(K)$. Then C_T may be thought of as a function of K, which can be called $F(K)$. Then,

$$F(K) = KA + C_t + \frac{f(K) \text{ADM}}{1000}$$

Now, if the first derivative, $F'(K)$, is set equal to zero and the resulting expression solved for K, there is obtained a value of K for which the total cost is a minimum. In practice it has been found through experience that for new pipelines in corrosive soils it is most economical to apply a reasonably good insulating coating followed by complete or partial cathodic protection. Such a combination results in total annual costs of the order of 1 to 2 percent of the total pipeline investment. As was shown in Part I of this paper, this amount may be less than the corresponding reduction in sinking fund deposit alone, let alone the other direct costs and all of the indirect costs.

That even partial protection may be of benefit is shown in the curves of Figure 3 and 4. Here the corrosion reduction curve of Figure 2 has been labeled such that the I_a abscissae are evaluated in annual costs in percent of initial investment. This curve appears labeled as curves 1 in Figures 3 and 4,

and has been recalculated to appear as years of extended life vs. annual cost in percent of original investment. Curves 2 show reduction in sinking fund deposit as replotted from Figure 1. Abscissae labeled "D" show the saving due to cathodic protection based on reduction in the deposit. Here the curves of Figure 3 indicate the existence of a maximum saving at some value of partial protection which would extend the system life from ten to 28 years. Figure 4 shows the case of extending the life from 20 years to greater values. Of course, other costs of corrosion enter to cause the engineer to go to more complete protection than the values indicated by the curves.

Summary

In summarizing it has been shown that for the pipeline example annual corrosion costs may be from 2 to 5 percent of the original investment. By means of proper corrosion control these costs may be replaced by coating and cathodic protection costs which are only from 1 to 2 percent of the original investment. Since the original investment runs into billions of dollars, cathodic protection becomes of great significance in the engineering economic picture.

The electrical engineer may well anticipate that cathodic protection will effect similar savings in other corrosion areas as well, such as the corrosion of power plant equipment, cables, substations, docks, ships, and, in fact, anywhere that metals are in contact with soils and solutions.

References

1. Herbert H. Uhlig. Cost of Corrosion to the United States. *Corrosion*, **6**, 29-33 (1950) Jan.
2. Doremus, Doremus & Parker. Engineering Aspects of Cathodic Protection as Applied to Pipelines. *Corrosion*, **5**, 273-281 (1949) Sept.
3. Peabody & Woody. Experience and Economic Benefits from Cathodic Protection on Gas Distribution Systems. *Corrosion*, **5**, 369-377 (1949) Nov.
4. R. M. Wainwright. Cathodic Protection on Distribution Systems. *Electrical News*, **12**, 33-53 (1942) May.

Bibliography

- Olson & Beezley. Practical Corrosion Control on Gas Transmission Lines. *Corrosion*, **5**, 249-253 (1949) Aug.
- Doremus, Doremus & Parker. Attenuation Equations Applied to Cathodic Protection by Distributed Drainage. *Corrosion*, **5**, 32-36 (1949) Jan.
- William J. Schreiner. Cathodic Protection Applied to Gas & Electric Utility Operations. *Corrosion*, **5**, 17-24 (1949) Jan.
- A. D. Simpson, Jr. Mitigation of Corrosion on City Gas Distribution Systems. *Corrosion*, **5**, 59-69 (1949) Feb.
- W. R. Schneider. Comparative Cost of Cathodic Corrosion Protection Equipment. *Pacific Coast Gas Association Proc.*, **30**, 165-169 (1939).

Effect of Heat Treatment and Related Factors On Straight-Chromium Stainless Steels*

By F. KENNETH BLOOM

Introduction

IN THE PAST ten years the straight chromium hardenable stainless steels have found a steadily increasing use in the petroleum industry. Their ability to resist attack in such environments as sour crude oil, carbonic acid and sulfur-bearing hydrocarbons coupled with their ability to be heat-treated to give a wide range of hardness or strength has led to applications in many oil and gas production fittings. Among these may be mentioned such uses as Christmas tree casing heads, flow beans, valve bodies, cages, stems, seats and the like.

Another attractive feature of these steels is their relatively low alloy content which makes them the least costly of the stainless alloys. This has also become an important consideration because of present day critical shortages in other corrosion-resisting materials and alloys containing nickel, copper and molybdenum. While exact figures are not available, it is probably safe to say that over 1,000,000 pounds of these alloys were employed by the industry in 1951.

In the search for further sources of petroleum the oil and gas industry finds itself faced with unexpected corrosion problems each time new types of fields are tapped. The trend in general has been to an increasing severity of conditions to which petroleum equipment is subjected. A recent example of this is the sour gas-condensate wells whose development has been accompanied by apparently new types of corrosion failures both in low and high-alloy high strength steels. While the origin and cure for this new problem are still being investigated it has already been observed that the heat-treatment of steels exposed to this environment has a decided bearing on their performance. In turn, this has focused attention on the effect of heat-treatment on corrosion resistance as well as its effect on strength and ductility.

For this reason it has been suggested that a review of the broader aspects of the relations between heat-treatment, mechanical properties and corrosion resistance of the straight chromium stainless steel would be timely.

In this paper an endeavor has been made to summarize those aspects of heat treatment which are common to the hardenable stainless steels and to indicate how these may vary for individual types within the group. General data and information have been chosen which it is hoped will be helpful to the metallurgist or engineer in choosing the grade



F. KENNETH BLOOM—A member of the Baltimore Section of the Armco Research Laboratories in the capacity of research metallurgist, he had close contact with many investigations relating to heat treatment and corrosion resistance of stainless steels. He has been active on a number of committees and in groups dealing with specifications for these steels, is the inventor of several patented processes and alloys and has contributed a number of technical articles in this field. After graduation from George Washington University in 1935 with a BS, he joined the Rustless Iron and Steel Corp. This company is now the Rustless Division of Armco and is devoted exclusively to manufacture of stainless steels.

Abstract

The hardenable straight chromium stainless steels find increasing application in the oil and petroleum industry where combined high strength and corrosion resistance are desired. To assist engineers in the proper selection of these alloys the effect of heat-treatment on their mechanical properties and corrosion resistance is reviewed. The general relationship between structural changes caused by heat-treatment and hardness, toughness and corrosion resistance is first discussed and specific data are then given for each grade. The undesirable effects of carburization are briefly discussed.

and heat treatment best suited for his particular application.

Composition of the Straight-Chromium, Hardenable Grades

Inspection of Table I will show that the nine standard alloys in this group contain chromium as the principal alloying element in amounts varying from about 11 percent to 18 percent, carbon up to 1.20 percent, and in some cases small amounts of the other alloying elements, mainly sulfur or selenium and nickel. Each of the alloys can be hardened by cooling from high temperatures, the maximum quenched hardness depending, as indicated, primarily on carbon content. They are all described as "martensitic" alloys because that is their matrix microstructure in the hardened condition.

Each of the grades has a particular reason for its development and final recognition as a standard alloy and it is pertinent to review this briefly. The progenitor of the group is Type 420. This is the original stainless steel developed in England for cutlery and similar applications. With a carbon content around .30 percent and with chromium at 13 percent, this alloy is readily hot forged and can be hardened to a level of hardness satisfactory for household knives. In this condition it is resistant to attack by food products. Early experience showed that its usefulness was restricted, however, to places where it could

* A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., October 1-3, 1952.

be used fully hardened. If tempered or softened, a serious loss in corrosion resistance occurred. It was found that this could be remedied by lowering the carbon content and the alloy now known as "Type 410" evolved. This grade could be tempered or annealed to produce a wide and useful range of hardness. Further research disclosed that additions of sulfur or selenium would help the machinability of these alloys and led to the free-machining counterparts, Types 416 and 420F. Type 403 grew out of the need for a special quality Type 410 capable of meeting the numerous rigid tests applied to turbine blades and other highly stressed members. Types 440A, 440B, 440C, and 440F were developed in response to the demand for a corrosion and wear-resistant steel which could be hardened to levels comparable to those of tool steels. Varying carbon contents in these grades provide slightly different degrees of hardness and toughness. Type 414 is a modification of Type 410 containing an addition of about 1.5 percent nickel, which gives somewhat improved resistance to corrosion in some media. Type 431 contains both a higher chromium content and a similar small amount of nickel. It represents about the highest practical alloy content possible in a quench-hardened stainless steel. Until the advent of the modern precipitation-hardening alloys this grade was the most corrosion resistant of the hardenable steels.

General Response to Heat Treatment

Before presenting data for individual grades it is instructive to consider the alloys as a group. They all react to heat treatment much like alloy carbon steels. Each is hardened by heating to high temperatures and cooling rapidly. Thereafter they may be reheated to low temperatures to relieve quenching stresses (stress-relieved) or tempered at higher temperatures to soften them to intermediate hardness levels. Process annealing is accomplished by heating just below their critical temperature, full annealing (except for Types 414 and 431), by heating just above the critical temperature and slow cooling.

Figure 1 is an attempt to depict the general trend of hardness, toughness and corrosion resistance when hardened samples are drawn at various temperatures through the stress-relieving, tempering and annealing ranges up to the critical point and above, where rehardening begins again. The trends

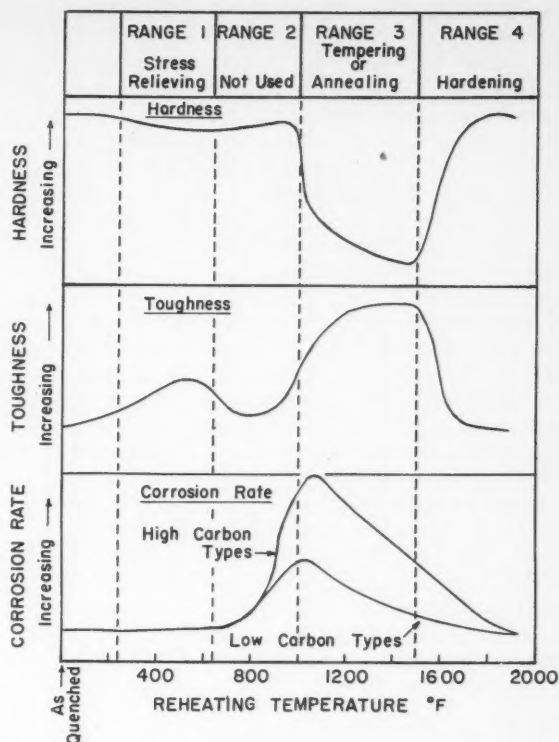


Figure 1—General trend of hardness, toughness and corrosion rate with heat treating temperature.

shown in this chart are characteristic of all the hardenable stainless steels, the exact level of hardness, toughness and corrosion resistance depending, of course, on the composition of each alloy. Toughness as illustrated in this figure is meant in a broad sense and may be considered as the property measured by such means as impact or cold bend tests. Corrosion resistance similarly is illustrated here as the rate of attack in any typical media to which these alloys might be exposed. The variation in corrosion rate with different temperatures of heat treatment may differ appreciably with different media but, with very few exceptions, the trends will follow the pattern shown.

While the change in properties with heat treating temperatures appears complex, it can be related to the alterations taking place in the structure of the

TABLE I—Composition of the Straight-Chromium, Hardenable Stainless Steels

Type No.	C	Mn Max.	P Max.	S Max.	Si Max.	Cr	Ni	Recommended Hardening Temp. °F.	Maximum Quenched Hardness	
									Brinell	Rockwell C
403.....	.15 max.	1.00	.040	.030	.50	11.50/13.50	.....	1700-1850	380-415	39-43
410.....	.15 max.	1.00	.040	.030	1.00	11.50/13.50	.....	1700-1850	380-415	39-43
414.....	.15 max.	1.00	.040	.030	1.00	11.50/13.50	1.25/2.50	1800-1950	400-450	42-47
416.....	.15 max.	1.25	*	*	1.00	12.00/14.00	.....	1700-1850	380-415	39-43
420.....	.15	1.00	.040	.030	1.00	12.00/14.00	.....	1800-1900	530-560	53-56
420F.....	.15	1.00	*	*	1.00	12.00/14.00	.....	1800-1900	530-560	53-56
431.....	.20 max.	1.00	.040	.030	1.00	15.00/17.00	1.25/2.50	1800-1950	410-440	42-46
440A.....	.60/.75	1.00	.040	.030	1.00	16.00/18.00	.....	1850-1950	555-590	55-58
440B.....	.75/.95	1.00	.040	.030	1.00	16.00/18.00	.....	1850-1950	575-610	57-59
440C.....	.95/1.20	1.00	.040	.030	1.00	16.00/18.00	.....	1850-1950	620-630	60-62
440F.....	.95/1.20	1.00	*	*	1.00	16.00/18.00	.....	1850-1950	620-630	60-62

* Phosphorus or sulfur or selenium 0.07 percent minimum, zirconium or molybdenum 0.60 percent maximum.

alloys as they are heated to progressively higher temperatures.

In the initial hardened condition the basic structure of every alloy in the group is martensite. The higher the carbon content, the harder and less tough the martensite structure will be. With the exception of a few media, the corrosion resistance of this phase is excellent, perhaps in part because of its homogeneity and also because in this form the maximum amount of chromium is dissolved in the matrix and is available to provide resistance to corrosion. In the lower carbon alloys, such as Type 410 or Type 416, the hardened structure may also contain very small amounts of delta ferrite. The presence of this soft and ductile phase rarely appears to have any significant effect on any property other than to slightly lower the overall hardness of the alloys. In those alloys having over about 0.25 percent carbon, the hard-matrix, martensite structure contains free iron-chromium carbides. These carbides contain substantial amounts of chromium; hence, in such alloys as Types 440A, 440B, 440C and 440F a higher amount of this element is added to maintain an adequate level in the matrix. These very hard and highly corrosion-resistant carbides contribute markedly to the hardness and wear resistance of the alloys.

In the free-machining grades the structure also contains non-metallic sulfide or selenide inclusions. These particles are very plastic at elevated temperatures and are deformed into elongated stringers during hot working. Heat treatment does not appear to affect their distribution or shape materially. Their presence tends to give a more fibrous structure to the steel, to lower its ductility and corrosion resistance and to appreciably aid its free-cutting properties.¹

The variations in hardness, toughness and corrosion resistance which take place on reheating may be traced primarily to changes in the basic martensite structure. To do this it is convenient to divide the heat-treating temperatures into four ranges:

Range 1.

Stress Relieving—Reheating chromium-martensite within the range of about 300 to 700 degrees F results in a very slight drop in hardness, a significant increase in toughness and no change in the original high level of corrosion resistance. The martensite is apparently toughened by the partial release of internal strain set up in the original hardening operation. In an exact sense, some rearrangement of the structure does occur in this range but it does not involve any loss of chromium from the matrix and is not believed to be significant insofar as corrosion-resisting properties are concerned.

Range 2.

Not Used—Between roughly 700 and 1000 degrees F there are at least two structural changes known to take place which are usually regarded as harmful in effect, so that this range is not recommended for heat treating any of the alloys. A secondary hardening effect is observed which reaches its height at around 950 degrees F. A noticeable loss in toughness

occurs and corrosion rates increase abruptly. The loss of corrosion resistance in this range is very marked in the case of the high-carbon grades. At the upper end of the range and above, the loss in corrosion resistance is so pronounced that the use of alloys containing over about 0.15 percent carbon is not normally recommended in such a condition of heat treatment. A clue to the secondary hardening, the loss in toughness and corrosion resistance, is found in the recent observation² that in this range a marked structural change is in progress. Decomposition of martensite into a structure of alpha ferrite and submicroscopic platlets of iron carbide occur at the lower end of the range and at the upper end the iron carbides have been observed to react with the matrix to form iron-chromium carbides. It is reasonable to suppose that in the immediate vicinity of each carbide the matrix must be severely depleted in chromium, creating a condition of extreme inhomogeneity. Under these conditions it is not surprising that corrosion resistance should suffer.

In the high-carbon and nickel-containing alloys the original quenched martensitic structure may also contain small amounts of retained austenite. When tempered in this range this decomposes to form fresh martensite. This is believed to contribute to the secondary hardening and loss of toughness in this range. Type 431 is particularly prone to this characteristic and the mechanical properties of the grade can be markedly affected by varying the hardening temperature, which affects the amount of austenite retained on quenching.

Range 3.

Tempering and Annealing—Between 1000 degrees F and up to the critical temperature, gradual coalescence of chromium carbides into microscopically visible particles occurs. As the carbides become coarser, hardness drops rapidly, reaching a minimum at the annealing range just below the critical temperature. Toughness sharply increases and corrosion rates improve gradually. In the lower carbon grades, while the corrosion resistance of material tempered in this range is generally not as good as that in the hardened and stress-relieved condition, it is still at a relatively high and useful level.

The high-carbon grades, on the other hand, do not sufficiently recover corrosion resistance to merit their use after this treatment. At these higher temperatures chromium is able to diffuse through the matrix and restore the severely depleted areas formed around the chromium carbides, providing they are not too numerous. In an alloy containing 0.10 percent carbon and 12.5 percent chromium, even if all the carbon were in the form of carbides, the matrix would lose only approximately 2 percent of the chromium for their formation, leaving over 10 percent, which when uniformly distributed, is adequate for a reasonable degree of corrosion resistance. In an alloy such as Type 420, however, with 0.30 percent carbon and 13 percent chromium, the formation of chromium carbides will result in the loss of around 6 percent chromium, leaving the matrix inadequately protected.

It might be noted in discussing this range that Figure 1 has been drawn to indicate a critical temperature of about 1475 degrees F. This value is approximately correct for all of the grades except Types 414 and 431. The nickel present in these two alloys depresses this temperature about 200 degrees F. Other than this, these alloys show the same trends as the other grades.

Range 4.

Hardening—Once the critical temperature is exceeded on reheating, the alloys begin to reharden unless they are cooled at very slow rates. As the temperature is raised, the hardness increases gradually and reaches a maximum at a temperature between 1700 and 1950 degrees F, depending on the grade. The recommended temperatures for full hardening of each alloy are listed in Table I. Partial or semi-hardening at intermediate temperatures serves no useful purpose and is not recommended for most grades. In the case of Types 410 and 416, however, it may sometimes be used for special reasons discussed in the following section.

If, instead of being quenched, these alloys are slowly cooled from this temperature range down to 1000 degrees F (usually at rates of 50 degrees F per hour or less) a structure of ferrite with relatively coarse spherical carbides is developed. Such annealing treatments will give the lowest possible hardness in each alloy and are occasionally used where this is necessary. The corrosion resistance of the low-carbon alloys in this condition is about the same as that obtained with subcritical annealing. The high-carbon alloys are detrimentally affected, as would be expected and are not placed in service in this condition.

Response of Individual Grades Types 403, 410, and 416

Mechanical Properties

These grades are grouped together since their compositions are similar and, with some exceptions, so are their properties.

Figure 2 shows the effect of heat treatment on the tensile and yield strength, elongation, reduction in area and Izod impact strength. These data are the average results of tests on bar stock of about one inch in diameter from a number of heats of the typical analysis shown. As mentioned previously, the addition of sulfur to the free-machining Type 416 does not affect the hardness, tensile or yield strength but results in slightly less elongation, reduction in area and impact strength, as the curves illustrate.

It will be noted in Figure 2 that up to 1400 degrees F the material was held at the tempering temperature for four hours. Below 800 degrees F, the time of tempering has little effect on hardness but at higher temperatures hardness decreases significantly with increased time. It has been shown that the effects of time and temperature can be interrelated and both expressed as a single tempering parameter of the form $T(20 + \log t)$, where T is

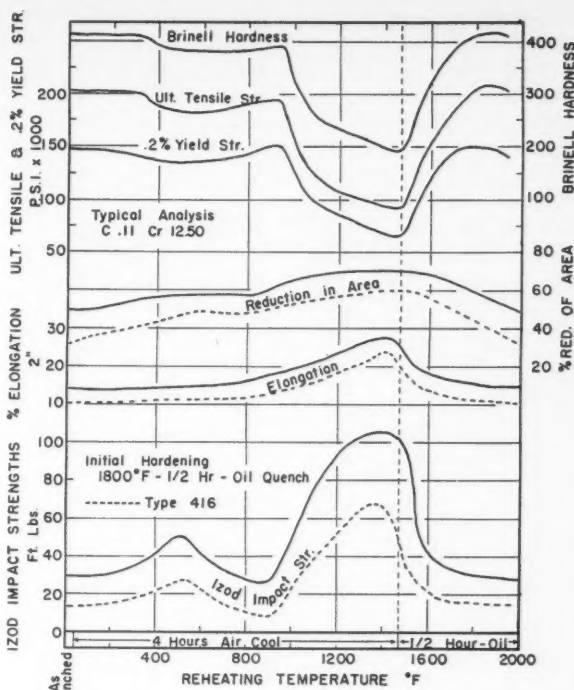


Figure 2—Effect of heat treatment on the mechanical properties of typical heats of Types 403, 410 and 416.

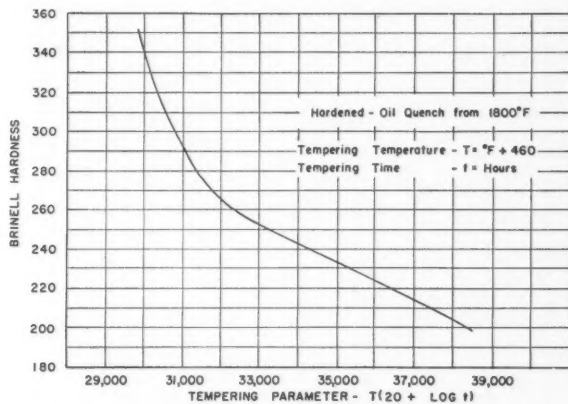


Figure 3—Master tempering curve for Types 403, 410 and 416.

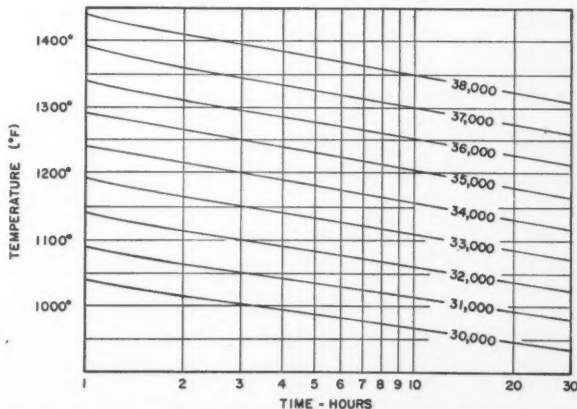


Figure 4—Chart for determining value of the tempering parameter for various combinations of temperature and time.

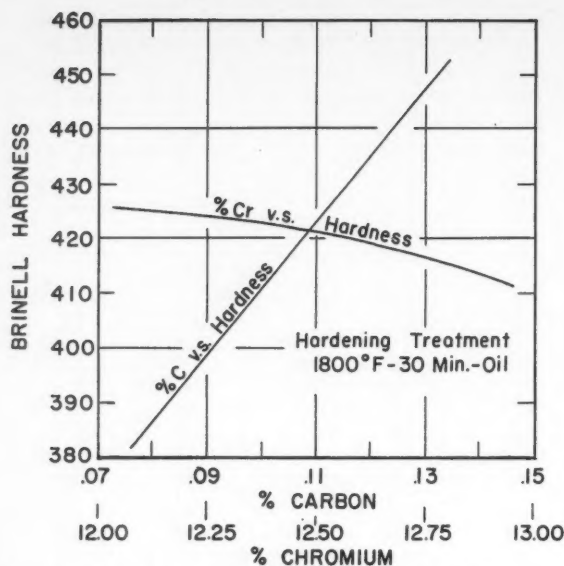


Figure 5—Effect of carbon and chromium on initial quenched hardness of Types 403, 410 and 416.

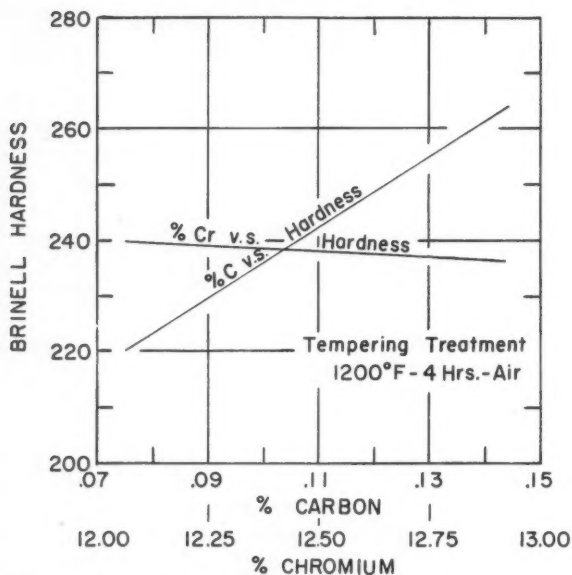


Figure 6—Effect of carbon and chromium on the tempered hardness of Types 403, 410 and 416.

the tempering temperature in absolute degrees and t is the tempering time in hours.³ Figure 3 is a plot of this tempering parameter against hardness. Figure 4 is a chart for determining the value of the parameter for any combination of temperature and time. These master curves can be used to estimate the tempering treatment to produce any particular hardness. If, for example, a hardness of Brinell 240 is desired, reference to Figure 3 indicates that the tempering parameter will be 34,200. Figure 4 shows that the latter value is equivalent to one hour at 1250 degrees F, 4 hours at 1200 degrees F, or 15 hours at 1150 degrees F. Any one of these combinations will provide the required hardness.

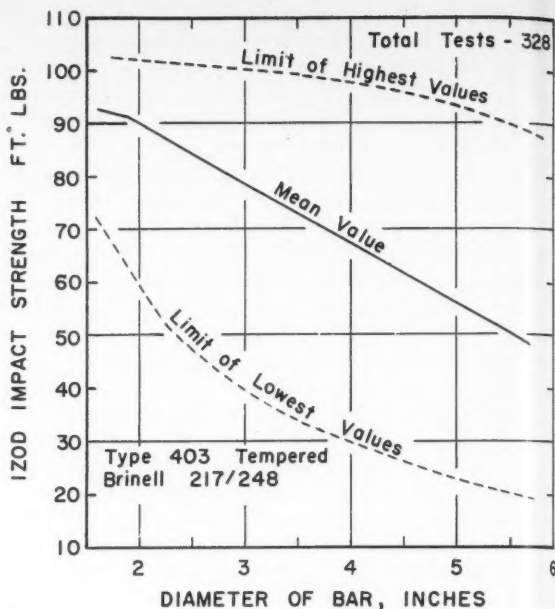


Figure 7—Effect of size on the Izod impact strength of tempered Type 403 bars.

Some emphasis should be placed on the fact that Figures 2 and 3 represent the response of material having an initial quenched hardness of Brinell 418. Quenched hardness will vary somewhat from heat to heat, depending primarily on the carbon and to a lesser extent on the chromium contents. Figures 5 and 6 show the effect of variations in these two elements on initial quenched hardness and on hardness of material tempered at 1200° F. Heats higher in initial quenched hardness show higher hardness after tempering and those lower in quenched hardness are softer; hence, when heat treating within narrow hardness limits, preliminary pilot tests to establish the exact tempering temperature are sometimes desirable. These figures are useful as a guide in selecting the approximate tempering treatment, which can then be easily established exactly by a few preliminary tests.

Since impact toughness is frequently a matter of concern in heat treating these grades, it may be of interest to point out a factor which influences this property and which has not received much attention in the literature. This is the effect of size. Experience has revealed that as the cross section of bars increases, there is a tendency to obtain somewhat lower impact strength. Figure 7 shows the results of Izod impact tests carried out on a large number of Type 403 bars varying from two to five inches in diameter, which were tempered in the range of Brinell 217 to 241. These tests represent longitudinal specimens taken from the intermediate location in the sections.

For some applications of these grades a Brinell hardness in the range of 260/320 is required. This can be obtained by two entirely different heat treatments. The better known procedure is to fully harden the material and then temper back to hardness level. Such a tempering treatment is usually

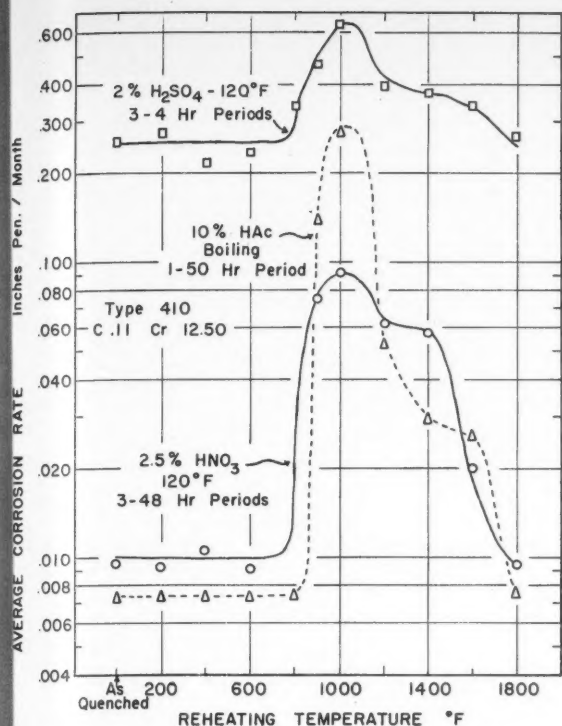


Figure 8—Effect of heat treatment on the rate of corrosion of Type 410 in dilute sulfuric, acetic and nitric acids.

carried out at around 1000 degrees F. Reference to Figure 2 shows that in this range hardness is falling very rapidly with small increments in temperature. As a result, tempering to a narrow hardness range is difficult and requires very close control of temperature and tempering times.

The same hardness may be secured by heating the material just above the critical temperature and quenching. This treatment results in partial hardening, producing a structure of finely dispersed martensite, ferrite, and carbides. Temperature control is somewhat less critical and material treated in this way generally exhibits somewhat better machinability than hardened and tempered stock. Mechanical properties resulting from semi-hardening are equivalent to those obtained by tempering except that slightly lower impact strengths are experienced. Typical mechanical properties brought about by this type of treatment are given in Table II. Certain variations of this type of treatment are described in the patent art.⁵ Semi-hardening has been used in the heat treatment of a number of parts such as steam valve stems, which have performed very satisfactorily despite the slightly lower toughness.

Corrosion Resistance

Figures 8 and 9 summarize the results of laboratory corrosion tests on several Type 410 heats in four quite different media. In each instance corrosion rates are best in the hardened and stress-relieved condition, climb abruptly in the unfavorable tempering range of 800 to 1000 degrees F, and fall again at higher tempering temperatures. It is interesting to

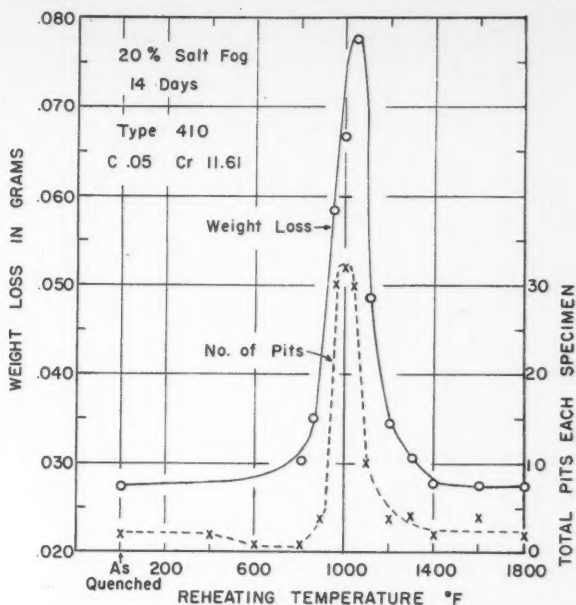


Figure 9—Effect of heat treatment on corrosion resistance of Type 410 in 20 percent salt fog.

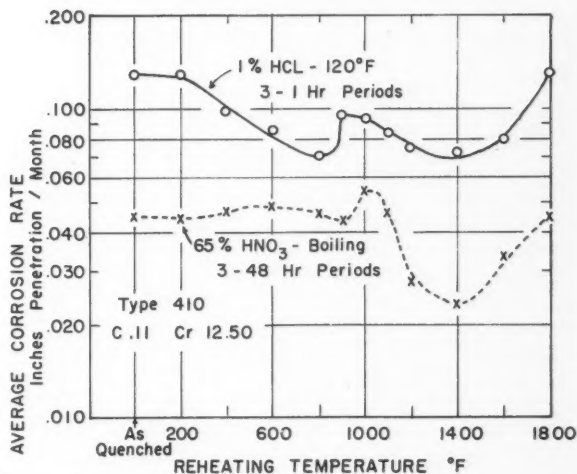


Figure 10—Effect of heat treatment on the rate of corrosion of Type 410 in dilute hydrochloric and 65 percent nitric acids.

note that the degree of variation in corrosion resistance with tempering temperature is dependent on the test media. In 10 percent acetic acid the highest rate is 40 times greater than the lowest, while in 2 percent sulfuric acid this ratio is only 3. The results of salt fog tests shown in Figure 9 are also interesting since corrosion in this medium proceeds primarily by a pitting mechanism. Both weight loss and number of pits per specimen follow exactly the same trends with heat treatment exhibited in the media which produce uniform attack.

Every rule has its exception and departures from the expected seem especially likely to crop up in the field of corrosion behavior. Figure 10 shows the results of tests on the same lots in boiling 65 percent nitric acid and in 1 percent hydrochloric acid at 120

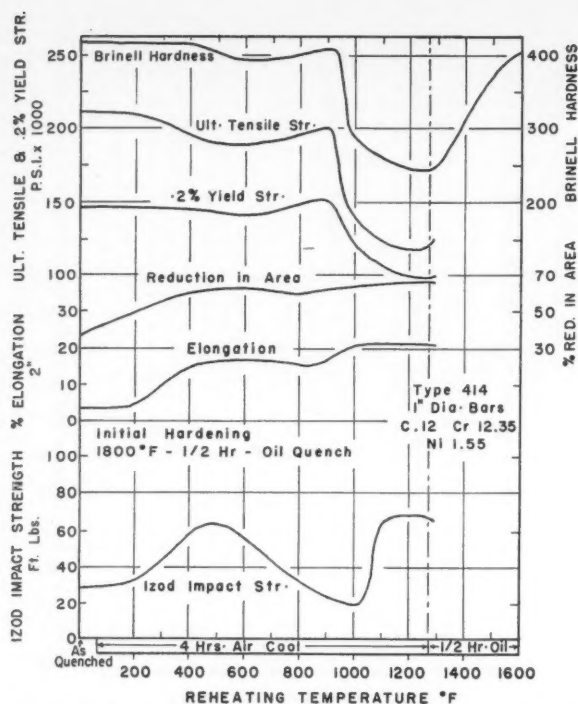


Figure 11—Effect of heat treatment on the mechanical properties of Type 414.

degrees F. In these two media material annealed at 1400 degrees F had slightly lower corrosion rates than when hardened and stress-relieved. In both cases a slight tendency toward increased rates is exhibited after 1000 degree F tempering, but in general the trend of the curves is abnormal. No ready explanation is available for this unexpected performance. With all of the hardenable stainless grades corrosion rates in boiling nitric acid are lower with annealed material than with fully hardened, even in the high-carbon grades. This test has been used quite widely to determine the general effectiveness of heat treatment of the austenitic stainless steels. Its application to the straight-chromium, hardenable grades for the same purpose could be seriously misleading.

Semi-hardening has been mentioned above as a possible method of heat treating these grades. Table II compares the corrosion resistance after this treatment with material fully hardened and tempered to the same hardness. Semi-hardened material is slightly better.

Besides media which produce general attack and those which cause pitting, there is another type of corrosion that is of particular interest at the present time and apparently quite different in its mechanism from the other two. This has been named "sulfide corrosion cracking." At the National Association of Corrosion Engineers Conference held at Galveston, Texas, during March of this year, several papers were presented on this subject which in-

cluded a few test results on the straight-chromium, hardenable stainless steels. Fraser and Treseder⁶ include data on a Type 410 wrought material having a hardness of Rockwell C28, which was apparently susceptible to hydrogen sulfide embrittlement. On the other hand, cast Type 410, presumably annealed, was quite resistant. A report by NACE Technical Practices Committee 1-G⁷ shows again that a wrought 12 percent chromium steel of Rockwell C33 was embrittled while a soft cast material appeared satisfactory. Prange⁸ gives the results of some cathodically pickled samples hardened from 1700 degrees F and drawn at 1050 degrees, 1120 degrees and 1200 degrees F. The as-quenched samples and those drawn at 1050 degrees F were embrittled while the one drawn at 1120 degrees F was very slightly susceptible. The one drawn at 1200 degrees F was not embrittled.

TABLE II
Semi-Hardened Versus Hardened and Tempered Type 410
Mechanical Properties and Corrosion Resistance

	Hardened and Stress Relieved 1800° F., ~30 Min. Oil Quench + 1000° F., ~4 Hr. Air Cooled	Semi-Hardened 1600° F.-1 Hr. Air Cooled
A. Mechanical Properties:		
Ultimate Tensile Str. psi.....	155,000	145,000
2 Percent Yield Str. psi.....	130,000	120,000
Elongation Percent.....	17.0	15.0
Reduction of Area Percent.....	64.0	45.0
Izod Impact Str.-Ft., Lbs.....	51-67	19-28
Brinell Hardness.....	311	298
B. Corrosion Resistance		
	Corrosion Rate in Inches Penetration/Month	
2.5 Percent Boiling Nitric Acid, 3-48 Hr. Periods.....	.0924	.0512
10 Percent Boiling Acetic Acid, 1-50 Hr. Periods.....	.2772	.0262
2 Percent Sulfuric Acid-120° F., 3-4 Hr. Periods.....	.6314	.3445

TABLE III
Effect of Heat Treatment on Susceptibility to Hydrogen Embrittlement

Grade	Condition	Treatment °F	Angle of Cold Bend to Fracture	
			Initial	After Cathodic Treatment
410	Annealed	1400	180 OK	180°—OK
	Hardened and Stress Relieved	1800+730	180 OK	40°
431	Annealed	1225	180 OK	180°—OK
	Hardened and Stress Relieved	2000	180 OK	31°
440C	Annealed	1650	180 OK	110°
	Hardened and Stress Relieved	slow cool	40	20°

* Wire specimens 0.060" diameter charged with hydrogen cathodically in 10 percent NaOH solution, 60 minutes at one ampere/sq. in. Wire bent around a 0.06" diameter mandrel.

TABLE IV
Comparative Corrosion Tests on Types 410 and 431 Hardened and Stress Relieved and Hardened and Tempered

Corrosion Test Media				Corrosion Rate Inches Penetration/Month			
				Type 410 1800° F.-Oil Quench		Type 431 1900° F.-Oil Quench	
Reagent	Conc. % Vol.	Temp.	Time	+ 400° F.	+ 1200° F.	+ 500° F.	+ 1150° F.
H ₂ SO ₄	2.0	120° F.	3 x 4 Hrs.	0.273	0.542	0.160	0.168
HCl	.25	95° F.	5 x 48 Hrs.	0.045	0.045	0.0002	0.0003
Acetic Acid	10.0	Boil	1 x 50 Hrs.	0.0006	0.031	nil	0.0003
Formic Acid	1.0	95° F.	5 x 48 Hrs.	0.0019	....	.0002	....

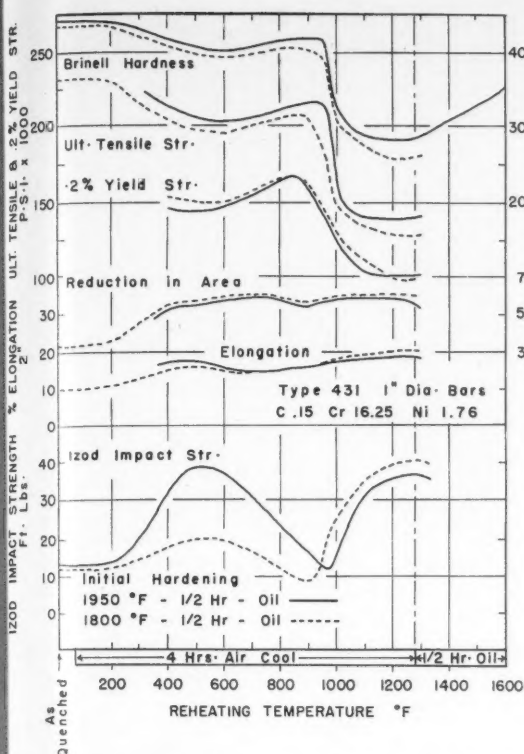


Figure 12—Effect of heat treatment on the mechanical properties of Type 431.

If sulfide corrosion cracking, as is now suspected, is related to the susceptibility of material to hydrogen embrittlement, these results are not altogether surprising. It has been demonstrated before that the hardenable stainless steels can be embrittled if hydrogen is introduced into the hardened structure. Interestingly enough, the same material, if annealed, is not susceptible. Zapffe and Specht⁹ conducted bend tests on wire samples of Types 410, 431 and 440C after cathodic charging in 10 percent sodium hydroxide. Some data from their paper which illustrate this very clearly are given in Table III.

The tendency of martensitic structures toward hydrogen embrittlement is not confined to the chromium alloys, as Fraser, Treseder and others have shown, but appears to be characteristic of high strength steels. The question of particular interest, then is at what strength level can these alloys be safely employed without fear of embrittlement? Investigations which should provide some information on this question is in progress in Armco laboratories and it is hoped that data will be available in the near future.

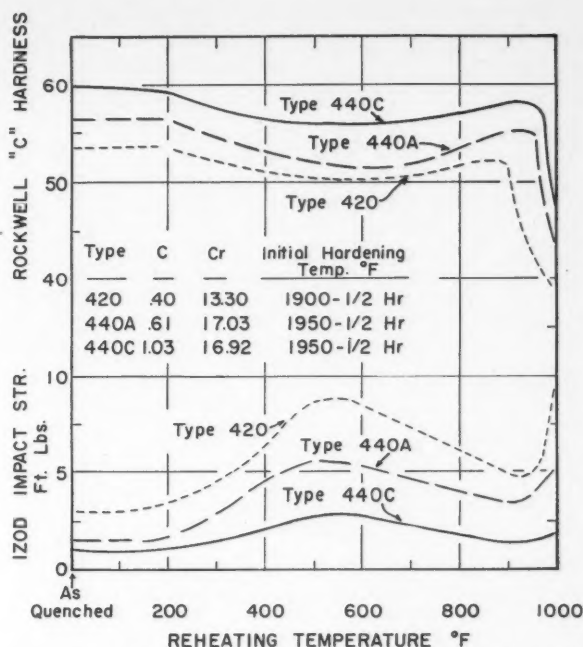


Figure 13—Effect of stress relieving Types 420, 440A and C on their Rockwell hardness and impact strength.

Types 414 and 431

Mechanical Properties

These two nickel-containing grades may be conveniently grouped together because their response to heat treatment is similar. Figures 11 and 12 show the effect of varying tempering temperatures on the mechanical properties of a typical heat of each grade. In Figure 12, Type 431, two curves are shown for each property, one for material initially hardened at 1800 degrees F; the other, for material hardened at 1950 degrees F. With increasing hardening temperature this grade retains significant amounts of austenite in the quenched structure. When drawn at

TABLE V
Corrosion Fatigue Strength of Type 431
Versus 15% Cr and .50% C Steel and 18% Cr-8% Ni

Grade	C	Cr	Ni	Condition	Brinell Hardness	Endurance Limit* 107 Cycles	
						In Air	In 3% Salt Spray
.50 C	.48	.....	.....	Cold Rolled	280-301	psi. 55,400	psi. 11,200
15% Cr	.12	14.75	.....	Hard. & Temp.	218-221	55,400	25,100
431	.25	17.10	1.16	Hard. & Temp.	274-384	73,300	33,600
302	.11	18.32	8.23	Cold Rolled	242-255	53,200	39,200

* Reversed Bending Stresses.

TABLE VI
Mechanical Properties of Hardened and Stress Relieved Types 420, 440A, B and C
(Average Properties of 1" Diameter Bars)

TYPE	HARDNESS RANGE		AVERAGE MECHANICAL PROPERTIES				
	Brinell	Rockwell	Ultimate Tensile Strength psi.	.2 Percent Yield Strength psi.	Percent Elong. in 2"	Red. of Area Percent	Izod Impact Range Ft., Lbs.
420.....	470-530	C48-53	230,000	195,000	8	25	5-15
440A.....	490-530	C49-56	260,000	240,000	5	20	3-6
440B.....	520-590	C53-58	280,000	270,000	3	15	2-5
440C.....	540-620	C55-60	285,000	275,000	2	10	1-5

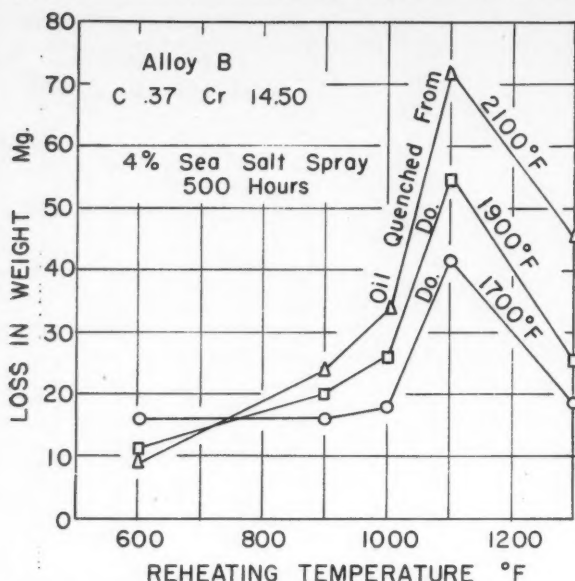


Figure 14—Effect of stress relieving Type 420 on its resistance to corrosion in 4 percent salt spray.

low temperatures this austenite is not affected and its presence adds to the notch toughness. At higher temperatures the austenite decomposes on cooling from tempering, forming fresh martensite, which detracts from toughness. The high side of the hardening range produces the maximum hardness and toughness when material is then stress-relieved, while the low side gives maximum toughness when tempering follows quenching.

Both grades begin to reharden when heated above 1250 to 1300 degrees F. Since they cannot be tempered over these temperatures, softening below about Brinell 250 is impractical. Full annealing by slow cooling from above the critical temperature is not feasible as the nickel content makes the austenite-ferrite transformation extremely sluggish.

Corrosion Resistance

Heat treatment affects the corrosion resistance of these two alloys in a manner similar to Types 403, 410, and 416. Table IV lists the results of corrosion tests on Type 431 and compares it with some of the other hardenable grades. For most environments the hardened and stress-relieved condition is the most resistant. However, as Zapffe's data in Table III show, under conditions favorable to hydrogen embrittlement, the reverse is true and the annealed structure will be best.

TABLE VII
Corrosion Rates of Types 420, 440A and 440C in
Boiling 65% Nitric Acid

Grade	Treatment °F.	Brinell Hardness	Corrosion Rate Inches Penetration/Month 1—48 Hour Period
420.....	1900 + 500	514	.0480
	1900 + 1200	248	.0239
440A.....	1950 + 500	524	.0412
	1950 + 1400	217	.0081
440C.....	1950 + 500	555	.0761
	1950 + 1400	241	.0462

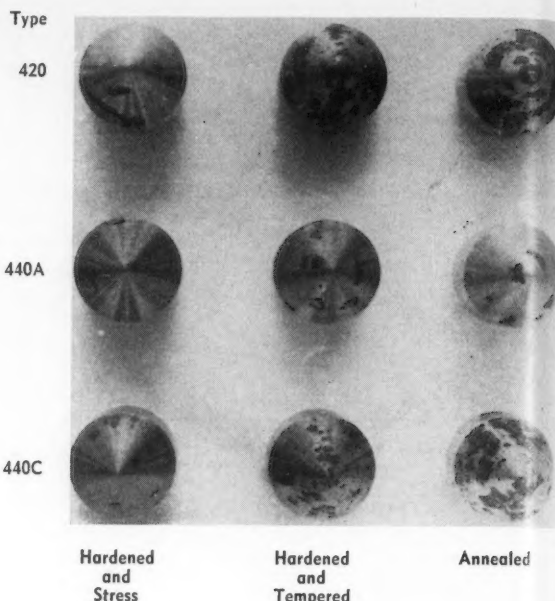


Figure 15—Appearance of cone-type specimens of Types 420, 440A and 440C exposed to 4 percent salt spray, 100 hours.

The nickel content of these alloys gives them added resistance to attack in chloride-containing media. Type 431 has been found to possess unusual resistance to the combined effects of alternating stresses and corrosion in such environments. Corrosion fatigue tests conducted by Gough and Sopwith¹⁰ disclosed that exposed to 3 percent salt fog this alloy was markedly superior to carbon steels, better than a 15 percent Cr alloy and approached the endurance limit of cold worked 18 Cr-8 Ni steel. Data abstracted from their paper are given in Table V.

Types 420, 420F, 440A, B, C and F

Mechanical Properties

For reasons discussed previously, these alloys are used in service only in the hardened and stress-relieved condition. Their general level of corrosion resistance is sufficiently similar so that the choice of grades usually depends only on the level of hardness and toughness desired. Figure 13 summarizes the effect of re-heating hardened samples of Type 420, 440A and 440C at various temperatures up to 1000 degrees F on hardness and impact strength. The response of the free-machining Types 420F and 440F is the same as that of their counterparts, Types 420 and 440C. The hardness and toughness of Type 440B lie between that of Types 440A and 440C. In each case the optimum stress-relieving temperature for maximum toughness is around 500 degrees F. Table VI lists the full mechanical properties of each grade after stress-relieving at this temperature.

Corrosion Resistance

Figure 14 is taken from data obtained by Strauss and Talley¹¹ on specimens of compositions corresponding approximately to that of Type 420 exposed to 4 percent sea salt spray for 500 hours. When this

steel is drawn above 1000 degrees F the loss in corrosion resistance is very marked. These curves are interesting because they show the effect of initial hardening temperature and show that high hardening temperatures are not desirable. Figure 15 is a photograph of salt spray specimens of Types 420, 440A and 440C which were exposed to 4 percent salt spray for 100 hours. Each grade was tested in the hardened and stress-relieved (500 degrees F), tempered (1400 degrees F), and full-annealed condition (1650 degrees F-slow cool). The superiority of the stress-relieved samples is quite evident. Type 440A was somewhat more resistant than the other two grades, perhaps because it has the largest amount of free chromium not combined with carbon.

Table VII gives the results of tests on these materials in boiling 65 percent nitric acid and again shows the peculiar tendency of this particular medium to preferentially attack hardened structures.

Effect of Factors Related To Heat Treatment

Carburization

Any discussion of the influence of heat treatment on stainless steels would be incomplete which failed to mention the effect of carburization sometimes occurring in heat treatment. If the hardenable, straight-chromium grades are hardened under conditions which permit carbon to enter the surface, the chromium there will gradually be converted almost entirely to chromium carbides. In this condition the alloys lose their resistance to corrosion almost completely. In some cases, particularly with Types 431 and 440C, the introduction of even small amounts of additional carbon will cause the surface to develop a soft but rather brittle layer of austenite which may also be damaging to mechanical properties.

Carburization can be readily avoided if it is appreciated that these alloys must be kept away from carbonaceous materials at high temperatures. The most common cause of this difficulty is the attempt to protect the surface of the steel during heat treatment by treating parts surrounded by charcoal, coke dust, cast iron turnings and the like. Another source of carburization is the rectifiers sometimes used in molten salt baths. Addition agents containing cyanides or other carbon compounds should be avoided as should the practice of placing parts coated with oil or grease in the furnace. Prepared atmospheres high in hydrogen and carbon monoxide and low in water vapor have been known to cause carburization.

Stainless steels can be satisfactorily hardened in electric furnaces, in oil or gas-fired furnaces or by induction heating. Experiments in Armco's laboratory have shown that moderately reducing atmospheres obtained by burning natural gas at an air-gas ratio of 6 to 8 will not produce carburization and will minimize scaling. Scale-free hardening can be obtained if desired by treating these alloys in specially dried atmospheres of hydrogen or cracked ammonia.

Sometimes it is desired to produce parts with high surface hardness coupled with a soft, tough core. Special nitriding methods have been developed for this purpose which give surface hardness in order of

Rockwell C65-73. Such treatments may lower the corrosion resistance to a degree, but nitrided parts have performed very well in steam valves, high pressure pumps handling crude oil and like applications.

Summary

The hardenable stainless steels have given excellent service in the oil and gas industry in a variety of applications. In the few instances where failures have been experienced they have often been traced to misunderstandings regarding the proper methods of heat-treating the alloys or to incorrect choice of grades and heat-treating methods.

In selecting one of these alloys for some particular application the design engineer and metallurgist should bear in mind that their properties can be varied through a considerable range by heat-treatment and that this applies not only to mechanical properties but to corrosion resistance as well.

The mechanical properties of the lower carbon alloys, such as Types 403, 410, 414, 416, and 431 are necessarily dependent on their composition and when these grades are to be heat-treated within a narrow range of mechanical properties this should be borne in mind. The steel mills and warehouses which supply these alloys make every effort to see that the material supplied will develop the properties desired. To do this most effectively however, requires specific knowledge of the intended application and the fabricating methods and heat-treatments to be employed. If such data is furnished by the oil and gas industries, the mills in turn will be found willing and able to offer assistance in furnishing a suitable grade and supplying information on the best heat-treatment.

Acknowledgment

The author expresses his appreciation for permission given by the Armco Steel Corporation to publish this paper. Thanks is also due to his several associates in the research laboratories who carried out the many tests over a period of years, which provided the data. He is especially grateful to N. R. Harpster for his assistance in preparing the figures.

Bibliography

1. The Corrosion Resistance of Free Machining Stainless Steel. S. P. Watkins. *Metal Progress*, **39**, 710-714 (1941).
2. Secondary Hardening of Tempered Martensitic Alloy Steel. W. Crafts and J. L. Lamont. TP 2439-Metals Technology. September, 1948, pp. 1-42.
3. Time-Temperature Relations in Tempering Steel. J. H. Hollomon and L. D. Jaffe. *Trans. Amer. Inst. of Mining and Metallurgical Eng., Iron and Steel Div.*, **162**, 223-249 (1945).
4. Isothermal Transformation, Hardening and Tempering of 12% Chromium Steel. R. L. Rickett, W. F. White, C. S. Walton and J. C. Butler. *Trans. Amer. Soc. Metals*, **44**, 138-175 (1952).
5. United States Patents 2,218,973 (Oct. 22, 1940) and 2,262,690 (Nov. 11, 1941).
6. Cracking of High Strength Steels in Hydrogen Sulfide Solutions. J. P. Fraser and R. S. Treseder. *Corrosion*, **8**, No. 10, 342-350 (1952) October.
7. Field Experience with Cracking of High Strength Steels in Sour Gas and Oil Wells. NACE TP-1G Committee report. *Corrosion*, **8**, No. 10, 351-354 (1952) October.
8. Hydrogen Embrittlement Tests on Various Sheets. F. A. Prange. *Corrosion*, **8**, No. 10, 355-357 (1952) October.
9. Effect of Composition, Heat Treatment and Cold Work on the Hydrogen Embrittlement of Stainless Steel Wire During Cathodic Pickling. C. A. Zapffe and O. G. Specht, Jr. *Trans. Amer. Soc. Metals*, **39**, 193-212 (1947).
10. Some Comparative Corrosion Fatigue Tests Employing Two Types of Stressing Action. H. J. Gough and D. G. Sopwith. *J. Iron and Steel Inst.*, **127**, 301-335 (1933).
11. Stainless Steels—Their Heat Treatment and Resistance to Sea-Water Corrosion. J. Strauss and J. W. Talley. *Proc. Amer. Soc. Testing Materials—Part II*, **24**, 217-258 (1924).

The Coupon Technique— A Valuable Tool in Corrosion Testing^{*}

By H. L. BILHARTZ and HOWARD E. GREENWELL

Introduction

THERE ARE MANY references in the literature of corrosion technology to the "coupon technique" as a means of assessing corrosion. Few discussions of corrosive oil or gas production fail to make reference to the results of coupon tests. However, little published attention has been directed to important details of this procedure. As a result, those inexperienced in the art often obtain erroneous impressions from reported data. It is believed that a clearer understanding of details will make this important tool more generally valuable.

The "coupon technique" embraces both physical and chemical concepts. Coupons are small metal plates which are weighed and otherwise prepared for exposure, exposed to corrosive fluids for a number of days, examined and cleaned of corrosion products after exposure and reweighed. Both qualitative and quantitative data are obtained. Careful examination and interpretation of the appearance of corrosion products adhering to the coupons afford valuable characterization of the type of attack which may be expected. The difference in weight determined after removal of the corrosion products places a numerical value on the corrosiveness. Coupons find widespread use in defining the corrosiveness of a particular environment and in controlling measures taken to control corrosion.

The purpose of this paper is to describe the manner in which one oil and gas producing company utilizes coupons in its corrosion studies. Procedure, application and limitations will be considered. Greatest emphasis is placed on procedure. The experience of this company has been confined to installation of coupons in surface equipment.

Coupon Material

The material from which a coupon is made is fundamental to the nature and amount of attack which will be experienced. It is necessary to choose a metal which will be sensitive to a wide range of corrosive conditions and not be subject to reactions which will form films on the surfaces which interfere with the measurements. Uniformity of specifications, availability, ease of reducing to the desired specimen, ease of removing corrosion products and economy are other requisites of a good coupon material.

These requirements suggest immediately that steel be chosen. There are an almost limitless number of alloys which can be used. It is generally accepted that corrosion rates of low carbon (less than 0.8 percent C) steels will not vary significantly with car-

HARRELL L. BILHARTZ—Senior Chemical Engineer in the Crude Oil Production Dept. of The Atlantic Refining Company, Dallas, currently is chairman of NACE TP-1 on Corrosion of Oil and Gas Well Equipment and TP-1C on Sweet Oil Well Corrosion. He also is vice-chairman of the NACE Membership Control Committee and past chairman of North Texas Section and is active in committee activities of the Natural Gasoline Association of America, API and a member of AIMME. He attended Southwestern University, Harvard and Massachusetts Institute of Technology and served three years in the navy in the World War II.



H. E. GREENWELL—Associate Chemical Engineer in The Atlantic Refining Company's Crude Oil Production Department, he is in charge of the company's corrosion studies. He engaged in corrosion control work for several years after graduation from University of Tennessee with a ChE degree. Mr. Greenwell is active in The Natural Gasoline Association of America and in NACE committee activities and is vice-chairman of TP-1C on Sweet Oil Well Corrosion. During World War II he served three years in the Army Air Force.

bon content. Low carbon steels are not prone to form protective films except those typical of the types found on producing equipment. If one stays within the limits of low carbon steels exact composition of the metal becomes unimportant and the physical condition of the metal is the determining consideration.

Steel shim stock has been found to possess a generous quantity of the requirements of a good coupon material. The exact composition of the metal is not known. One proprietary brand adopted as a standard has been found to possess highly satisfactory uniformity of physical properties. Two thicknesses are used to make coupons; 0.004-inch and 0.012-inch. At least 95 percent of the coupons used by this company have been made of these two thicknesses of steel shim stock.

Rarely, it has been desirable that a heavier coupon be used. The necessity of using a thicker metal usually arises from strength requirements, rather than extreme corrosiveness of an environment. Here again, exact composition of the metal is not felt to be the determining factor. Cold rolled 18 gage steel was chosen as the heavy coupon material. Since a very limited use of 18 gage coupons could be foreseen, it was a simple matter to purchase and store many years' supply of material obtained from one source. Minor variations which might result from difference in composition were thus eliminated. Shim stock and 18 gage sheet coupons have never been used in the same study unless specimens of both

^{*}A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952.

Abstract

The "coupon technique" frequently is mentioned in the literature as a method of assessing corrosion. Little discussion, however, has been devoted to important details of procedure. As a result, those inexperienced in the art often draw misleading conclusions from reported data. It is the purpose of this paper to present a detailed description of one company's method of using coupons. A clearer understanding of details will make this important tool more valuable.

The "coupon technique" is the only single method of study which measures the effect of both physical and chemical variables of the corrosion environment. Small metal plates, commonly called coupons, are weighed and otherwise prepared for exposure, exposed to the well fluids for a number of days, examined, cleaned of corrosion products and reweighed. Both qualitative and quantitative data are obtained. Careful examination and interpretation of the appearance of corrosion products adhering to the exposed coupons permits determination of the type attack which may be anticipated. The difference in weight before and after exposure places a numerical value on the corrosiveness.

This paper describes the coupon study procedure of one oil and gas producing company. Selection of coupon material, preparation of specimens, shipment and handling of coupons and the methods of exposing under various conditions are discussed in detail. In addition, techniques of evaluating and processing exposed coupons are considered. The construction of special equipment for processing and storage of coupons is described.

The coupon technique has been used to study corrosion under many conditions. A list of environments which have been investigated through the use of this method include gas lift and gas injection systems, water injection wells, gasoline plants, condensate wells, oil wells of all types, tanks, cooling systems, etc. In general, the results of studies of gaseous systems can be interpreted most literally. Studies of liquid systems have been very valuable, but, occasionally, variables not related to the corrosion process have influenced results. A brief resume of these and other pertinent factors concerned with the use and limitations of the coupon technique is given.

materials had been exposed together. Actually, little difference in the behavior of the two metals has been found in a given environment.

Preparation of Coupons

The 0.004-inch and 0.012-inch steel shim stock is purchased in rolls of 6 inches by 100 inches. Each roll is boxed and wrapped individually, and handling and storage problems are minimal. The 18 gage cold rolled material can be obtained in various size sheets to specification. Both materials are reduced to the desired specimen size by cutting on a conventional shop shear. It has been found necessary to reserve a set of shear blades exclusively for cutting the light gage material. Shears that are used more indiscriminately dull rapidly and produce a ragged edge on the thin shim stock. Cutting by this method quite naturally sets up strains in the metal adjacent to the edges. However, it is not felt that significant extraneous variables are introduced in this manner. Careful visual examination of several hundred exposed coupons has revealed no significant edge effects in corrosion patterns.

The coupons are stencilled with a hand punch set according to the identification system discussed later. One-quarter inch letters and numbers are used to give an easily legible identification. Each coupon is stamped near both ends on one side only. Stencilling

one side only permits specification of the position of the coupon with respect to its holder. The numbering process obviously creates severe strains in the metal. However, the strained area is quite small in relation to the total area of the specimen. Since all coupons are stamped in the same manner, the precision of measurement has not suffered, even though accelerated attack in this small area is common. No difficulty has arisen from this effect because of obliteration of the identification.

The steel shim stock is coated at the mill with a light film of oil. Each roll is packaged in a manner which excludes most atmospheric moisture. Usually the only surface preparation employed on coupons cut from shim stock is degreasing. This cleaning is accomplished by immersion in and washing with carbon tetrachloride. After the solvent wash, the coupons are placed under infra-red lamps where they dry very rapidly. Occasional spotting of the coupon surfaces has resulted from this procedure. Spotting can be avoided by using clean carbon tetrachloride. The coupons are left under the lamps until ready for the next step. Occasionally, coupons cut from shim stock will have very light rust spots from atmospheric corrosion. These are removed by careful sanding with crocus cloth. Only rarely has it been necessary to discard shim stock because of atmospheric attack.

The 18 gage material also is oiled, but it usually has a light film of rust on the surfaces. After the coupons cut from this material have been numbered and degreased, they are pickled. Immersion in 10 percent by volume hydrochloric acid for 30 minutes at room temperature has been found to yield a clean surface. The film of acid is removed by washing with fresh water, immersion in sodium bicarbonate solution and washing again with water. The coupons are then placed under the infra-red lamp.

The final step of preparation consists of weighing the coupons. The weight loss encountered in some studies is quite small. It is necessary that usual analytical accuracy, i.e. to the fourth decimal place, be observed. The specimens used are too long to fit the case of a standard analytical balance. To avoid sacrificing coupon area the balance case was enlarged. This was done by the laboratory carpenter at a cost of about \$50. Figure 1 is a picture of the balance.

The coupons are removed from the infra-red lamps a few at a time, and weighed on the modified analytical balance after they have cooled to room temperature.

Records

Each coupon is identified by a stamped letter and number. Designations used are A-1 through A-999, B-1 through B-999, etc. The coupons are numbered serially according to this system, without regard to the project for which they are intended. Each corrosion study project is assigned a code number which describes it and serves as a file number. Each box in which a pair of coupons is shipped also bears a serial number. A data sheet for recording laboratory and field information is pasted to each box.

Probably the most important requirement of a successful coupon program is the maintenance of ac-

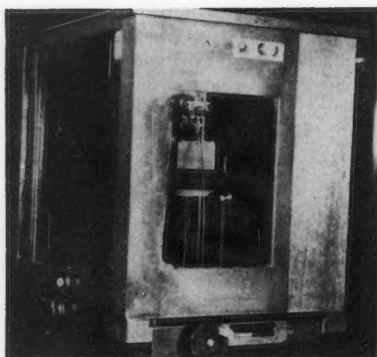


Figure 1—Analytical balance modified to handle large coupons.

Project No. <u>22-001</u>		Coupon Date: (1) <u>A-679</u>	
Project Title: <u>Carbon Steel</u>		Coupon Date: (2) <u>A-679</u>	
Director: <u>W. J. ...</u>	Coupon Weight: <u>0.12</u>	Coupon Size: <u>1.50</u>	Run No.: <u>0000</u>
Field: <u>...</u>	Coupon Date: <u>...</u>	Flow Line: <u>...</u>	
Location: <u>...</u>	Coupon Date: <u>...</u>		
Coupon No. (1) <u>...</u>	Coupon No. (2) <u>...</u>		
Exposure: <u>...</u>	Exposure: <u>...</u>		
Date Shipped: <u>...</u>	Date Shipped: <u>...</u>		
Date Rec'd: <u>...</u>	Date Rec'd: <u>...</u>		
Date Cleaned: <u>...</u>	Date Shipped: <u>...</u>		
Date Processed: <u>...</u>	Exposure (days): <u>...</u>		
Date Filed: <u>...</u>	Exposure (Vol. / Surface Area): <u>...</u>		
	Coupon Weight: <u>...</u>		
	Exposure: <u>...</u>		

Coupon No.	<u>A-679</u>	<u>A-679</u>
1. Init. Wt.	<u>0.1200</u>	<u>0.1200</u>
2. Final Wt.	<u>0.1195</u>	<u>0.1195</u>
3. Wt. Loss	<u>0.0005</u>	<u>0.0005</u>
4. % Wt. Loss	<u>0.42</u>	<u>0.42</u>
5. Avg. C	<u>...</u>	<u>...</u>
6. Pct. Wt.	<u>...</u>	<u>...</u>
7. Avg. Wt.	<u>...</u>	<u>...</u>
8. Vis. Exam.	<u>...</u>	<u>...</u>
9. Coverage	<u>...</u>	<u>...</u>
10. Descrip.	<u>...</u>	<u>...</u>
<u>A-679 has large red spot</u>		
<u>about 1/2 inch diameter</u>		
<u>they were in halos</u>		

Figure 2—Coupon control card.

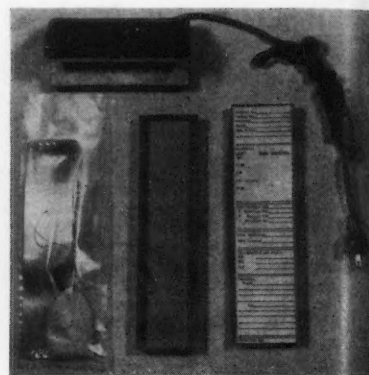


Figure 3—Shipping technique.

curate, usable records. With many projects going at once, it is evident that retention of the many details cannot be left to chance. The coupon records must serve several purposes. It should be possible for the persons preparing and processing the specimens to organize their work directly from the records and to make necessary entries in the records as the work progresses. It is desirable that the records be set up so that each step can be noted in logical order. The data should be readily accessible for evaluation and all of the pertinent information should be available in one place.

Control of the many necessary records is maintained through a file card system. These cards form the working basis of the entire coupon program. They provide both a permanent history of all coupon work and a ready means for determining the status of any particular study project. Since coupons are customarily exposed in pairs, data concerning two coupons are placed on each card. Both sides of the 5-inch x 7-inch card are used to record the information. In addition, a photograph of both exposed coupons is attached. Both sides of a typical control card are shown in Figure 2. Two separate files of cards are maintained: One for coupons which have been completely processed and the other for uncompleted coupons and coupons to be made. Cards are filed in the "completed" file according to project number. The more active file is divided into two parts. All cards relating to coupons which are in some stage of processing or exposure are arranged according to project in one section. The other section is divided into 31 parts, corresponding to the days of the month. Cards are initiated several weeks in advance and placed in this file according to the date that coupons are to be shipped. The status of any project can be determined at a glance.

In instances, it has been desirable to have a readily available index based on chronology. A catalog listing all coupons serially is kept to satisfy this requirement. Since this record serves chiefly as an in-

dex, only a few key facts concerning the coupons are noted. This record is far less important than the control card system.

Shipment

Coupon studies were inaugurated on a rather limited scale. It was possible to employ elaborate means of protecting the coupons in storage and shipment. Mineral spirits (petroleum base paint thinner) was found to be well suited to this purpose. Small cans were adapted to contain several dozen coupons and these containers were filled with mineral spirits in which the coupons were kept immersed. This procedure required a degreasing step in the field just before installation of the coupons. Most coupon installations and removals were performed by laboratory personnel, so that no undue difficulties were posed by this somewhat cumbersome arrangement.

The coupon technique proved to be very useful and the number of concurrent studies grew rapidly. It became necessary to ship the specimens to field personnel, who did the installing and removing. A new method of shipment soon became necessary. Of the many ideas which were examined, the use of sealed plastic bags proved to be best and was adopted. Bags are made from thin polyethylene tubing which is purchased in rolls of several hundred feet in length. The tubing is cut to length and sealed at the ends with a special iron made for this purpose. The pair of weighed coupons is placed inside two bags so that they are protected by a double thickness of plastic. A small cloth bag of desiccating material is placed in the inner bag next to the coupons. Drierite and activated alumina have been used as desiccants. Polyethylene is somewhat permeable to air, but it has been found that coupons can be stored in this manner for at least 30 days without damage. The bagged pair of coupons is placed in a cardboard box made especially for this purpose and shipped to the field. The bags and boxes are retained by the installer for return of the coupon. The bags

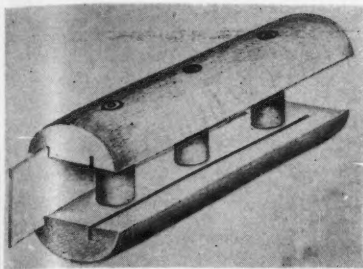


Figure 4—Bakelite coupon holding fixture.

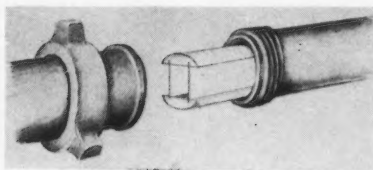


Figure 5—Placement of the coupon-holding fixture in a flow line.

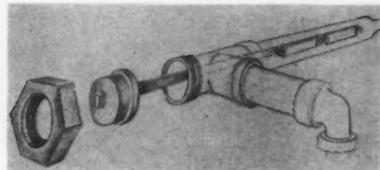


Figure 6—Coupon Holder adapted for high pressure installations.

can be sent by First Class Mail, and many of the difficulties of the former method have been eliminated. This procedure is illustrated in Figure 3.

Coupon Holders

The location of the coupons in the environment being studied must be chosen with care. Obviously, it is most desirable that the specimens be exposed in the part of the system about which there is the most interest. Usually, this is the well itself. Since a large number of wells have to be studied, the cost of the coupon exposure must be kept low. The practice of inserting the coupons at a point close to the well-head in the flow line has been adopted as a practical compromise. The sensitivity of the coupon corrosion rate measurements depends to a great extent upon the ratio of area to weight of the specimen. It is desirable that this ratio be made as great as possible. Since the thickness of a given specimen is bound by practical limits, the coupon must be made as large as possible. The length and weight are similarly limited, so that the final coupon size must be a compromise.

There are several requirements which determine the nature of the device used to hold a coupon. It is desirable that the specimens be inserted in the stream so that their major surfaces are parallel to the flow and perpendicular to the ground. Installation in this manner eliminates many of the effects of turbulence and sedimentation in the stream. The specimens must be held securely to minimize vibration and prevent loss, but, at the same time, the smallest area possible must be obscured. The coupons must be insulated so that they are electrically isolated from other metals. It must be possible to insert and remove the coupons readily and the procedure must not interfere unduly with production. Above all, the installation must be safe.

Different holder designs have been devised to meet varying conditions. The most widely used of these was developed for relatively low pressure work, although it has been used at pressures up to 700 pounds per square inch. The unit consists of a coupon holding fixture and a short section of flow line designed to receive and retain the fixture. The holding fixture is fabricated of canvas laminated bakelite. The construction of the fixture is depicted in Figure 4. The slots milled in the main members can be made of different widths to accommodate different gauge cou-

pons. The main members have been turned in a lathe to give an overall diameter of three inches. The fixture holds two coupons, 2-1/16" x 9-1/2". This holder was designed to be placed in a 2-inch flow line. The free area through a cross section of the Bakelite fixture is the same as the cross sectional area of two inch pipe. The fittings to hold the fixture are assembled in this order: 2-inch by 3-inch swaged nipple, 3-inch collar, 3-inch by 10-inch nipple, 3-inch hammer union, 3-inch by 2-inch swaged nipple. This group of fittings is made an integral part of the flow line. It is, of course, necessary that valves be so placed in the system that the unit can be isolated and bled down. Changing coupons usually requires about ten minutes. Where this procedure has interfered unduly with production, a by-pass arrangement has been necessary. The Bakelite fixture can be constructed for about \$20. Figure 5 shows the placement of the holder in the line.

It is apparent that this arrangement would not be satisfactory for pressures of 1000 pounds per square inch or greater. A suitable holder for studies in condensate wells and other high pressure installations was adapted from an OCT flow tee. This device is shown in Figure 6. The modification consisted of welding a rectangular bar 3/8-inch by 1 1/2-inch x 48-inch to the cap. The coupons are clamped to the bar with small blocks of Bakelite so that they lie parallel to the bar. In addition to the tee, a six foot length of 3-inch pipe and a swaged nipple of the proper size are required to construct a coupon station. Since the flow tee was designed for easy, safe opening, it is a simple matter to install and remove coupons. The flow tee offers an additional advantage in that it has a port for bleeding pressure built into the cap.

These two holder designs are used in most of the field coupon studies of this company. Modifications have been devised to meet certain specialized requirements such as heater treaters, gas intercoolers, engine cooling systems and water injection plants.

Installation, Exposure and Removal

Installation and removal of the specimens frequently is done by field engineering or operating personnel. They, quite naturally, have a primary interest in the studies and it is only through their unflinching cooperation that tests of any extent can be conducted. During the period of exposure, production data are carefully kept and any unusual variations

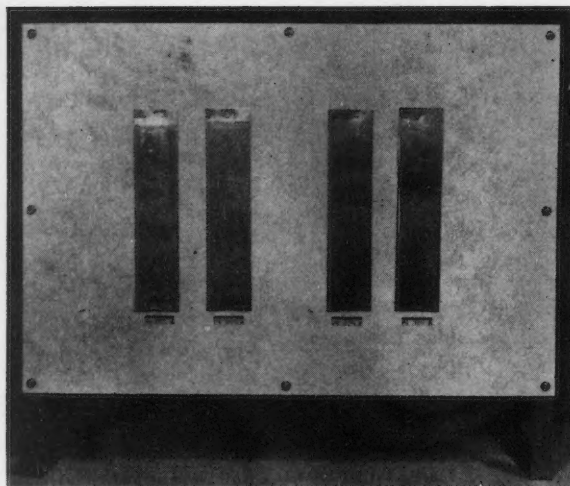


Figure 7a—Front view of photographing easel.

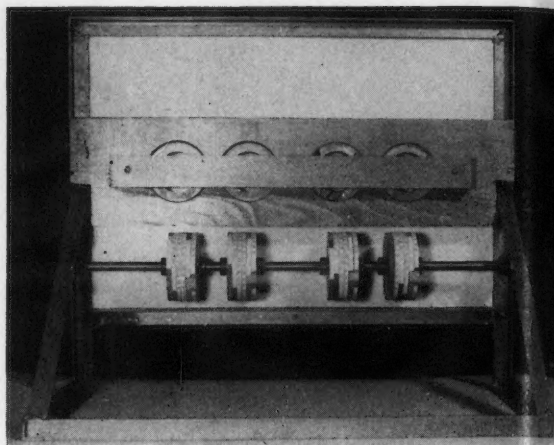


Figure 7b—Rear view of photographing easel.

in the performance of the well are noted. Frequently, water samples are collected during the period. The duration of exposure usually is 14 or 28 days. Rarely, it has been desirable to have more lengthy tests.

At the end of the proper number of days, the coupon station is bled down and opened and the specimens are removed. Care is taken not to handle the surfaces of the coupons with bare hands. Finger prints, left accidentally, become plainly visible during subsequent processing. Coupons are wiped completely dry with a clean rag, placed in the desiccated box, sealed and mailed back to the laboratory.

Visual Observation

Upon receipt at the laboratory, processing of the coupons begins with a careful visual inspection. Both surfaces of each coupon are rated according to the percentage of area covered with corrosion products. This system is, of course, arbitrary and many environments produce a surface which cannot be rated in this manner. However, when the conditions of exposure do produce variation in coverages, this concept has proved quite valuable. It has been found to correlate well with weight loss and its chief value lies in characterizing degree, when several variables are being investigated in a given environment.

Because many coupon exposures do not yield surfaces which are susceptible to such simple interpretation, it is necessary also to describe the affected parts of the surfaces. Both the apparent nature of the corrosion product and the severity of attack must be considered. The scale is described according to color, appearance and thickness. The severity of attack is appraised by noting pit formation and etch marks. In certain studies, notably those concerned with gas condensate systems, it has proved enlightening to examine coupon surfaces under low (X 40) magnification. Microscopic examination has not been practiced routinely, because of the large number of specimens handled and the time which would be required to inspect each coupon.

Photographing

The value of the permanent record of the appearance of the coupon before removal of corrosion products has been proved countless times. The numbered side of each coupon received is photographed in black and white. A small print is made for routine record purposes and attached to the permanent record control card. Large prints are made for special study as necessary. Taking close-ups to show the elusive surface details requires the most painstaking work. Much time was spent in developing a satisfactory, reproducible procedure. After a proper technique was developed, it remained only to devise a coupon holder which requires little adjustment or manipulation to make photographing a rapid process. A number of Alnico magnets were mounted behind a board large enough to provide a background for four coupons. The surface of this board was covered with a flat white plastic and a frame was built to hold this device in a vertical position. Four wheels, bearing a series of numbers, were mounted at the back. Slots were cut in the board so that it is possible to dial any desired number to identify four coupons at a time. The holder is shown in Figures 7a and 7b.

Removal of Corrosion Products

There are countless procedures for removing corrosion products from coupons. While no claim of unqualified superiority is made for the method described here it has been investigated thoroughly and found to yield satisfactory, reproducible results.

Cleaning begins with a thorough degreasing in carbon tetrachloride. The coupons are immersed and scrubbed as necessary.

Removal of the corrosion products is effected by making the coupons cathodes in an electrolytic cell. Lead anodes are used and the electrolyte is 10 volumes of concentrated sulfuric acid to 90 volumes of water. The electrolyte is inhibited with 0.1 percent Quinoline Ethiodide. The coupons are cleaned for 30 minutes at a current density of 0.1 amp per square

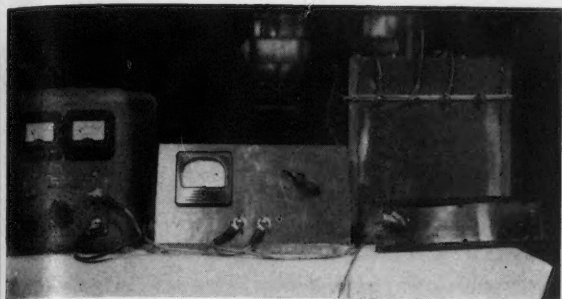


Figure 8—Coupon cleaning apparatus.

inch. They are removed from the acid bath, washed in running water, immersed in sodium bicarbonate solution for five minutes, washed again and dried under the heat lamps. Weighing completes the processing.

The number of coupons which can be cleaned simultaneously depends, of course, on the DC supply. It was decided to base the process on an ATR rectifier rated at 16 amps DC. Two cells, each holding four coupons, were built and two rectifiers were purchased. Thus, it is possible to process a large number of specimens in a day.

The cells were fabricated of canvas laminated bakelite. Each cell is constructed to receive four bakelite frames, each holding one coupon. Slots were milled to receive the frames so that insertion of coupons to be cleaned can be done rapidly. The cells are built so that one inch separates each electrode. Early experiments showed that ordinary grades of lead were unsuitable for use as anodes. The copper content was sufficient to cause copper plating of the coupon. A special low-copper lead used in telephone cable sheaths was found to be satisfactory. Electrical contact to the coupons is secured through stainless steel clamps which had to be made for this purpose. Stranded stainless cable and stainless bus-bars were used throughout. All solder joints were made with the low-copper lead. A control panel comprised of an ammeter, a rheostat and the necessary terminal posts was built to facilitate erection and disassembly of the unit. The cleaning apparatus is shown in Figure 8.

Expression of Corrosion Rates

The generally accepted expression "inches per year penetration" (IPY) is used to convey the results of coupon exposure. The weight loss is calculated as IPY as follows:

$$\begin{aligned} \text{IPY} &= \frac{\text{weight of metal removed}}{\text{density of coupon} \times \text{area of coupon (both sides)} \times \text{duration of exposure}} \\ &= \frac{\text{weight loss (g.)}}{7.83 \frac{\text{(g.)}}{\text{(cm}^3\text{)}} \times \frac{1 \text{ (cm}^2\text{)}}{.061 \text{ (in}^2\text{)}} \times \text{area (in}^2\text{)} \times \text{duration (days)} \times \frac{1 \text{ (years)}}{365 \text{ day}}} \\ &= \frac{\text{weight loss (g.)}}{0.352 \times \text{area (in}^2\text{)} \times \text{days exposed}} \end{aligned}$$

The density factor used here is that of cold drawn steel.

IPY, as a measure of corrosion loss, shows average or over-all loss and may be misleading where pitting



Figure 9—Storage dessicator.

is a primary factor. However, it serves as a better comparative basis than many other expressions which might be used. In general, comparison of IPY values is a sound practice only when similar environments of exposure are being considered. In other words, each type of corrosive system has its own criteria of coupon behavior. The use of IPY values permits comparison of the work of different investigators, provided their coupon practices are similar. Interpretation of IPY values is a much more complex subject than can be considered here.

Storage

When coupon studies were begun, it was decided that a comprehensive library of exposed coupons would be of value. In order to meet the storage problem which was not long in developing, it became necessary to have a large dessicator cabinet. Commercial cabinets were found to be expensive and not entirely suitable for the intended function. It is of interest to relate the details of construction of a very satisfactory unit.

A used 9 cubic foot refrigerator, purchased for \$5, formed the basis of the unit. The working parts were removed and a rectangular duct made to contain about 75 pounds of desiccant and a blower were fitted to the back. Air is continuously circulated through the desiccant bed and storage space. The desiccant is changed about every thirty days when the relative humidity reaches 10 per cent. The several hundred coupons stored in the cabinet are readily available for immediate reference. A photograph of the dessicator is given in Figure 9.

Some Application of Coupons

A comprehensive evaluation of the use and interpretation of coupon exposures would be a proper subject for a paper far longer than this. However, it would not be amiss to consider, in a most general fashion, some of the more common applications of the coupon study technique.

It has been the authors' experience that the simplest systems suitable for coupon investigation are those involving a sweet "residue," or stripped gas. Gas lift and gas injection systems fall into this category. Usually, residue gas from gasoline plants is used. Gas obtained from gas wells is passed through separation equipment before use for this purpose and it is similar in properties to the residue gas. It has been found that, in a given system at specified conditions of temperature and pressure, corrosion of coupons will correlate exactly with volume of gas flowed past the coupons. Corrosion of equipment is simply related to volume of gas, so that properly interpreted coupon tests are definitive of actual corrosion. Thin (0.004-inch) coupons are best suited for this type study. Loss of 10 per cent of the original weight in a 14-day exposure is not uncommon in some localities. The usual remedial measure for corrosion of this type is dehydration of the gas. Effectiveness of dehydration can be followed very simply with coupons. As long as the gas is properly dried, there will be no attack on coupons.

The coupon technique is well adapted to study of many gas condensate wells. However, because this corrosion environment is quite complex it seldom is wise to rely solely on results of coupon tests. It is characteristic of condensate well corrosion that corrosiveness varies considerably throughout a system. Therefore, the coupon will directly reflect corrosiveness only at the point of exposure. The picture is further complicated by the observation that coupon corrosion rates will vary somewhat with the length of exposure. The following generalities are used in interpreting results obtained from exposing coupons to condensate production:

Wells which are sufficiently corrosive to require equipment replacements in two years, or less, will have coupon corrosion rates of at least 0.010 IPY.

More moderately corrosive wells, which might suffer significant damage in five to eight years, will have coupon corrosion rates of about 0.005 IPY.

When coupon attack falls to the 0.001 IPY level, corrosion is considered negligible.

These IPY values are those which have been adopted by the Natural Gasoline Association of America Condensate Well Corrosion Committee. It is to be emphasized that they are average figures, stated as generalities. Condensate well corrosion is not assessed on the basis of coupon exposures alone. The 0.012-inch coupon has been used in most condensate studies. Both 14 and 28-day exposures have been employed. There are many possible solutions to condensate well corrosion.

While coupons have been of little value in evaluating resistant alloy or coated tubing they usually are quite effective in studying inhibitors, if the point of introduction of the chemical is known.

Experience will not support many generalizations concerning the use of coupons in oil wells, both sweet and sour. In some instances they have proved extremely valuable while in others they have been worthless, if not misleading. It has almost been a matter of installing a small number of exposures in a field to test the technique before using coupons on a broad scale.

Of course, there are some interfering conditions which can be foreseen such as deposition of paraffin which is the chief offender. Some oil wells flow very erratically and so the ratio of water to oil varies greatly from day to day and within a day. The corrosiveness of this production is thought to be similarly variant and in cases such as these, it has been impossible to obtain coupon corrosion rates which correlate with history of corrosion damage in the well.

Formations of films on surfaces of coupons has a great effect on the corrosion rate measured over a short period. This effect has been especially significant where sulfide films are concerned and it is here that fulfillment of the requirements of an ideal coupon material has been realized least. It is impossible to cite average IPY values for oil well exposures. In most cases, it has been possible to obtain measurable datum levels of corrosion.

Effectiveness of inhibitors can be evaluated and acceptable correlation with actual experience has been obtained. Both .012-inch and 18-gage coupons have generally been used in studies of oil wells with exposure periods of 14 or 28 days the rule.

Other applications of coupons include corrosion studies of tanks, salt water disposal and injection systems, heater treaters, gas intercoolers in gasoline plants and engine cooling systems. Although many of the remarks above will apply to these applications each has its own peculiarities, which need not be discussed and it should be remembered most coupon studies are intended to be used comparatively.

Coupons have been of greatest value in determining the effects of remedial measures and the variation of corrosiveness with other factors in the same environment. It is not often that coupon exposures furnish a completely reliable sole criterion of corrosiveness.

Conclusion

The value of control coupons in corrosion studies is unquestioned. While coupons, like any tool, are subject to limitations in application, they offer the corrosion engineer a convenient method of obtaining evidence which represents the damage which occurs to equipment. The results of coupon tests depend on a great number of factors. Many of these are subject to the control of the investigator and many are not. It is highly important that the coupon technique be devised with appreciation for this fact.

DISCUSSION

Discussion by C. M. Schwab, Otis Pressure Control, Dallas, Texas:

The proved valuable coupon tests as discussed in this paper would be of even greater importance if

the coupons be made of metals similar to the tubular goods used in the wells tested.

For example:

N-80 Coupon for N-80 Tubing

J-55 Coupon for J-55 Tubing

9% nickel alloy coupon for 9% nickel alloy tubing, etc.

The coupons should probably be placed in the tree upstream of the choke not downstream in the turbulent "blast" area.

The 3-inch holding device in a 2½-inch flow line and the 2½-inch holding device in the 2-inch flow line would probably also create turbulent flow around the test coupons.

Reply by H. L. Bilhartz and H. E. Greenwell:

The questions which Mr. Schwab has raised are extremely important to the practice of investigating corrosion with coupons. They are questions which every investigator must answer to his satisfaction before undertaking studies of this nature.

Before dealing directly with Mr. Schwab's first proposal, it is believed that it would be well to review briefly the objectives of coupon testing. Generally speaking, tests with coupons are undertaken for three purposes:

- 1) to obtain data which can be correlated with other factors to establish degree of corrosiveness.
- 2) to aid in establishing control of a preventive program where the remedial program involves the imposition of changes in properties of the system, and
- 3) to evaluate the performance of a given alloy in a specific environment.

The greater part of our work has been undertaken for the first two purposes. It will be realized that the results of coupon tests can be applied only in a relative way. The coupon technique is only one of the tools used in investigating corrosion. Of the many criteria of a corrosive well, not one can be applied literally to define the corrosiveness of the well. It is only through appraisal and application of several criteria that corrosiveness can be determined. A coupon corrosion rate of 10 mils per year does not mean that the tubing will be attacked at that rate,

regardless of the material from which the coupon was made.

In choosing a coupon material, the factors of practicability, reproducibility and freedom from random extraneous effects introduced by the material are the prime considerations. If a material which possesses these qualifications can be found, the exact chemical composition and physical properties of the material are of secondary importance. It is believed that N-80 or J-55 coupons would meet the last two requirements set forth above. However, from a practical standpoint it would be extremely difficult to reproduce both the chemical and physical properties of grade N-80 or J-55 tubing in a coupon. Since other materials which will yield satisfactory results are readily available, no reason can be found for attempting to duplicate these properties.

On the other hand, if one is interested in evaluating the behavior of alloys in a given environment, certainly, the specimens must closely represent the physical and chemical properties of the material used in the equipment. Extensive tests of this type were conducted by the NACE in condensate wells. The results of these tests were applied directly to the selection of alloys which would be resistant to this corrosive environment. Experience since has shown that the tests were quite rigorous and the materials which appeared to be best on the coupon tests have yielded good service.

In regard to the question of where to place test coupons, it is felt that this again is a relative matter. In weighing the pros and cons of this question, it was decided that for our purposes, placement of the coupons at a point in the flow line downstream of the choke was the best answer. Among the factors which led us to this decision were the size of the specimen used, the expense of modifying the tree to allow insertion of the coupon and the ease of removing and installing the specimens. Care is taken to minimize the effects of turbulence through choice of the exact location of the exposure.

Undoubtedly, the holding devices described in this paper do create some degree of turbulent flow around the specimens. This would be true, to a varying degree, of any type of holding device which might be used. It is believed that other advantages offered by this particular design in a large measure offset any disadvantages created by turbulence.



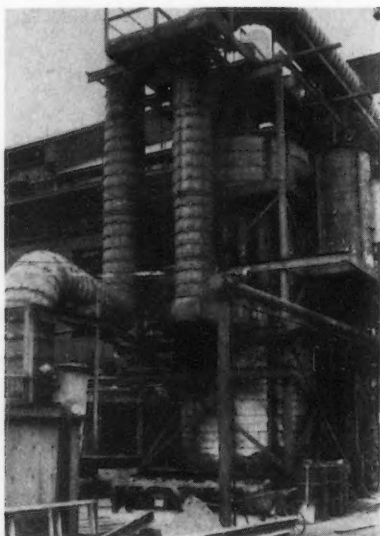
Discussions

Corrosion of Metals in Fluorine and Hydrofluoric Acid by G. C. Whitaker. *Corrosion*, Vol. 7, No. 9, 283-285 (1950) Sept.

(This discussion was inadvertently lost in filing. It is published with apologies to the author and discussors for the delay and in the belief the information included is significant.)

Discussion by Kempton H. Roll, Lead Industries Association, New York:

Conduits for the disposal of corrosive fumes are very often constructed of sheet lead curved and "burned" to form ducts. There are many instances, especially in the chemical and metallurgical industry where fumes containing fluorine and/or hydrogen fluoride along with moisture and other gases are being successfully handled in sheet lead ducts and in some cases, lead pipe. For example, many ore roasting operations evolve fluorine along with sulfur dioxide and other gases. In the recovery of these gases, particularly when converted to sulphuric acid, lead-lined ducts and chambers are employed. Those illustrated are part of the St. Joseph Lead Company's gas purification system at Joesphstown, Pa., at which



fluorine is encountered in the unpurified gas. At several large chemical plants handling fluorine gas, ducts constructed of sheet lead have been used satisfactorily for many years to conduct the fluorine under a variety of temperature and corrosive conditions. The ducts are made by curving sheet lead together and "burning" (welding) along the seam. They range from 10 to 16 inches in diameter and are usually supported by steel straps. In contact with fluorine gas, particularly in the presence of moisture, lead

is transformed into the fluoride behaving somewhat like lead sulfate, the fluoride coating or film on the lead surface prevents or substantially decreases further reaction. At temperatures up to at least 100 degrees C, lead is known to handle fluorine gas safely. Lead fluoride is soluble in nitric acid or sulfuric acid; insoluble in acetic, hydrofluoric or ammonia. Its solubility in water at 20 degrees C is 0.064 grams per 100 ml.

Discussion by Robert R. Pierce, Pennsylvania Salt Manufacturing Co., Philadelphia:

Several questions have been submitted on handling dilute hydrofluoric acid solutions and hydrofluoric acid fumes.

As hydrofluoric acid manufacturers, experience has lead us to adopt many nonmetallic materials of construction. For handling hydrofluoric acid solutions we like steel tanks lined with rubber, in turn, lined with carbon brick bonded with a special phenolic cement. We use this same type of construction to handle hydrofluoric acid fumes.

If the temperatures are high we substitute a Neoprene membrane for the natural rubber membrane. Where the pressure will allow, and the temperature is below 140 degrees F, we use Saran pipe without a steel casing. We have never found a suitable pump for these solutions. We make our own pumps which are composed of bronze, lined with $\frac{1}{4}$ to $\frac{1}{2}$ inch of a special plastic named MS-1.

A prominent pump manufacturer is now considering manufacturing a line of these pumps so they may become available for general use.

Comments by Ward E. Pratt, Worthington Pump & Mach. Co., Harrison, N. J.:

To avoid the possible general impression that may have been created here, i.e., stainless steels are not suitable for any condition involving fluorine—the following information may be of interest:

In the manufacture of phosphoric acid by the wet process, there are present in the process some fluorine, hydrofluoric or hydrofluosilicic acid, until they are removed. Acid solutions (phosphoric and sulfuric) and slurries, contaminated with fluorine compounds up to around three percent, must be handled at high temperatures. Worthite pumps and valves have been used for many years in Florida, Tennessee and Montana on these services and are considered excellent by the users.

Worthite is a complex alloy containing approximately 24 percent nickel, 20 percent chromium, 3 percent molybdenum, with small amounts of silicon, copper and manganese, the balance being about 48 percent iron. This alloy, therefore, may be classed as a high alloy or "super-stainless" steel.

Question by G. A. Marsh, Winnetka, Ill.:

What material of construction is used in pumping dilute aqueous HF solutions at room temperatures?

Reply by H. C. Whitaker:

Bronze pumps are in use for handling solutions containing up to 25 percent hydrofluoric acid and have given good service. For more concentrated acid Monel has better corrosion resisting properties. Karbate centrifugal pumps have been recommended for handling the waste acids produced as a by-product in the manufacture of phosphatic fertilizers.

Question by Edward Kauck, Minnesota Mining & Mfg. Co., St. Paul, Minn.:

Please discuss the effects of oxidizing agents on the corrosion of metals by dilute hydrofluoric acid.

Reply by G. C. Whitaker:

Corrosion of metals in dilute hydrofluoric acid is usually accelerated by the presence of oxidizing agents. The common practice of pickling stainless steel in a mixture of hydrofluoric and nitric acids is a good example. The presence of air in hydrofluoric acid has also been shown to increase the rate of corrosion from three to five fold on Monel metal.

Question by G. H. McIntyre, Ferrow Enamel Corp., Cleveland:

What recommendation can be given for best materials of construction to scrub waste gas streams containing 10 to 50 ppm of fluoride compounds?

Reply by G. C. Whitaker:

The usual installation for scrubbing waste gases for the removal of fluorine compounds is constructed with lead rubber lined steel or wood coated with tar. Any of these materials are suitable except for higher temperatures such as are encountered in smelters. At the higher temperatures Karbate or carbon brick construction might be useful.

Discussion by F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla.:

In commercial hydrofluoric acid alkylation units silicon content of the steel apparently does not affect the corrosion rate in anhydrous hydrofluoric acid. Silicon content varies considerably from steel castings to seamless pipe and seamless pipe to pressure vessel steel, the latter usually being quite low in silicon. In six years of operation of the alkylation units, differences in corrosion rates of the various steels are not yet discernible.

This uniform corrosion is quite reasonable when the corrosion process is examined. Scale up to several hundredths of an inch thick forms on the steel before the layer of corrosion product starts to loosen and another layer begins to form. Under these circumstances the corrosion rate is governed largely by diffusion instead of the reaction tendency measured in short-time corrosion tests. Except as composition of the steel might influence the adhesion of the scale, the composition will be relatively unimportant.

Aluminum Alloys for Offshore Pipe Lines by Edward T. Wanderer and Donald O. Sprowls. Corrosion, Vol. 8, No. 7, 227-233 (1952) July.**Questions by Bryant West Bradley, Shell Oil Company, Tulsa:**

1. What are the results of any tests conducted to determine the corrosion resistance of aluminum pipe to oil field brines containing H_2S , CO_2 , S and iron sulfide? What types of aluminum are the most corrosion resistant?
2. What is the tension strength of threaded connections and how does it compare to the pipe?

Remarks by Robert L. Bullock, Interstate Oil Pipe Line Company, Shreveport, La.:

Characteristics of aluminum alloy pipe such as light weight, resistance to corrosion and smooth interior surface make it attractive for oil and gas service, especially for offshore, swamp or marsh installation. Laboratory and field coupon tests are helpful in selecting the best alloy specimen; but, in proving a material there is no substitute for actual field experience. The Matagorda Bay installation will in time give this experience.

Reply by Edward T. Wanderer:

In answer to Mr. Bradley's questions, we can state that the corrosion of aluminum is not stimulated by the presence of hydrogen sulfide, carbon dioxide or particles of sulfur in oil well brines. As a matter of fact, acid gases such as hydrogen sulfide and carbon dioxide not only are innocuous but in many cases have an inhibiting action. Localized corrosion, however, seems to be promoted by brines containing iron sulfide particles which settle on the surface of the aluminum. Limited field tests of Alclad aluminum pipe handling sour crude oils containing such brines indicate that the clad product possesses a resistance to perforation that justifies more extensive service investigations.

With regard to the strength of threaded joints, tensile tests have been made on aluminum tube with threaded and coupled joints. Alloy 61S-T6 was used for both the tube and the couplings and threads were API 5A round threads, 10 per inch for one group of samples and American Standard tapered pipe threads for the other group. Results were as follows:

Type	Size	Ultimate Ratio Percent	Yield Ratio Percent
API	2½" Sch. 40	89	88
API	2½" Sch. 80	86	85
API	2½" OD x ⅜" W.	93	91

It should be noted that the results are based on the average of three tests for the API joints, whereas, the average of two tests was the basis for the American Standard joint test results. The yield loads were determined at 0.2 percent offset in a 10-inch gage length. The actual ultimate and yield strength of the tubes exceeded the minimum guaranteed properties for 61S-T6 tube; the ratios of minimum guaranteed strength to actual strength were as follows:

It thus appears logical to assume that for design purposes these ratios could be applied to the load

figures in the table to determine the ultimate and yield loads for pipe made of material just meeting the specification requirements.

We are entirely in agreement with Mr. Bullock's remarks. As is so often true on corrosion questions, it is necessary to wait some time before a final story can be written.

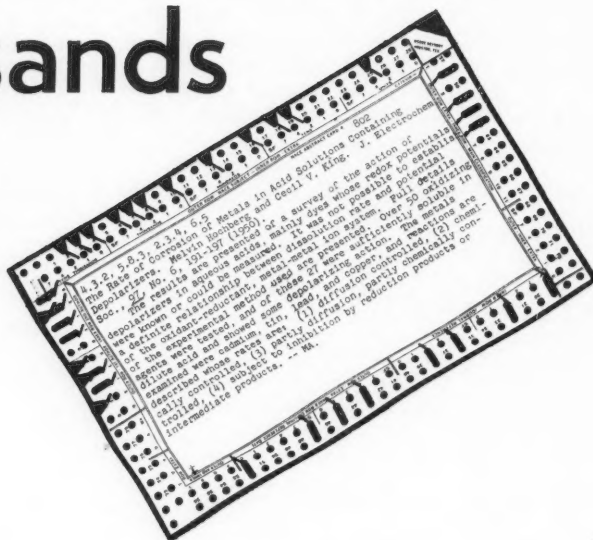
Type of Joint	Tube Size	Ultimate Load, Lb.		Ratio of Ultimate Loads Percent	Yield Load, Lb.		Ratio of Yield Loads Percent
		Plain	Coupled		Plain	Coupled	
API 5A Standard Round Threads-Non-Upset Couplings	2 1/4" Sch. 40 Pipe	74480	67570	91	69430	63730	92
	2 1/2" Sch. 80 Pipe	100530	84430	84	94530	80830	86
	2 3/4" OD x 1/2" W. Tube	105430	88500	84	99430	82730	83
American Standard Tapered Pipe Threads-Standard Pipe Couplings	1" Sch. 40 Pipe	23765	11690	49	.....	.....	..
	2" Sch. 40 Pipe	50950	23980	47	.....	.....	..
	3" Sch. 40 Pipe	104390	48300	46	.....	.....	..

a key to the work of thousands

NACE ABSTRACTS PUNCH CARDS

\$75

SUBSCRIPTION
1953 Calendar Year
(About 2000 Cards)



Carefully Selected from More Than 500 Periodicals
All Over the World

A Few
Sets of
1952
Cards
Available

In January the NACE Abstract Card Service began its third year. More than 4200 cards were issued in 1951 and 1952 to nearly 100 subscribers. These cards are 8 x 5 inches in size, of good quality buff cardstock, with a McBee 2-hole punch scheme. They are pre-indexed by author, periodical and year, and cross-indexed typically up to 5 times per card with a random number system. Coding is based on the NACE Abstract Filing System Index. About half the holes on the card are left unassigned, permitting supplementary indexing where needed. Weigh the advantages of this comprehensive service which covers not only most of the major technical periodicals in the world but also books, pamphlets and worthwhile literature issued by manufacturers.

Calendar Year 1953 Subscriptions Are Being Accepted Now!

Write A. B. Campbell, National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Texas

Figure 1-
of the mo

Topic of the Month

Aluminum Coiled Tube

By EDWARD T. WANDERER*

ALUMINUM coiled tube has been produced for many years, but only recently has it come to be recognized as a standard material for instrument air lines. Other applications include steam tracer lines, automotive air brake lines, hydraulic lines and refrigeration tubing. In many of these applications, aluminum has definite advantages over formerly-used materials.

One of the major factors contributing to the increased interest in aluminum coiled tube is economy, since the cost-per-foot of aluminum tube may be as low as 40 percent of that of copper tube. The cost spread between the two materials varies to some extent with size, tending to increase with increasing size.

Other factors which have stimulated the use of aluminum coiled tube include light weight, availability in long lengths up to 1000 feet and mechanical characteristics which are similar to those of previously used metal tube. The fact that aluminum has about $\frac{1}{3}$ the weight of copper makes the long lengths particularly interesting from a handling standpoint. For example, a coil of $\frac{1}{4}$ -inch O.D. x .032-inch wall aluminum tube, 1000 feet long, weighs only about 26 pounds.

Aluminum alloys, 3S-O and 4S-O, have historically been used for coiled tube, but an alloy, B50S-O, having comparable resistance to corrosion and better mechanical characteristics, has enabled Aluminum Company of America to market an improved coiled tube known as Alcoa "Utilitube." This product pro-

* Sales Development Division, Aluminum Company of America, New Kensington, Pa.

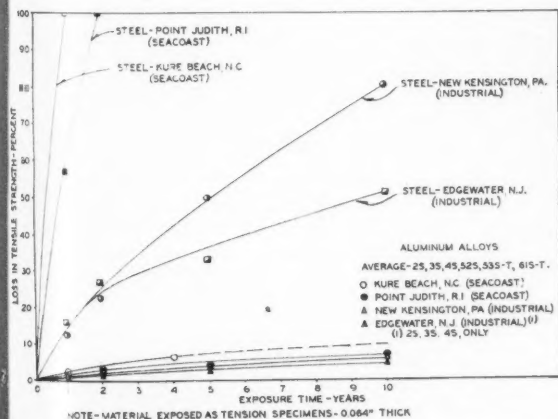


Figure 1—Graph showing results of atmospheric corrosion tests at four of the more severe exposure stations used by Alcoa Aluminum Research Laboratories.

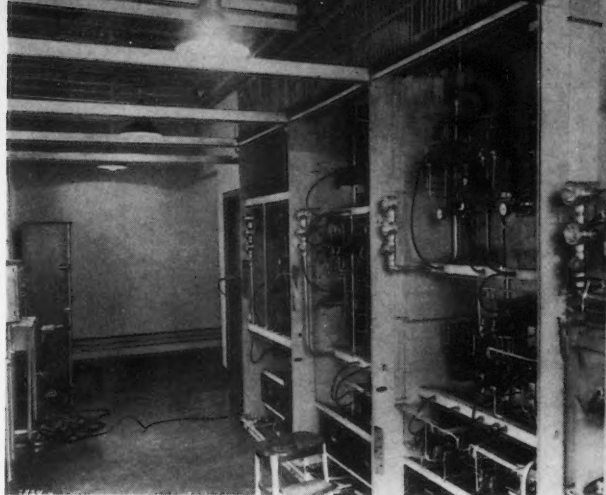


Figure 2—View of reverse side of panel board in a modern petroleum refinery. Banks of aluminum tubes are shown.

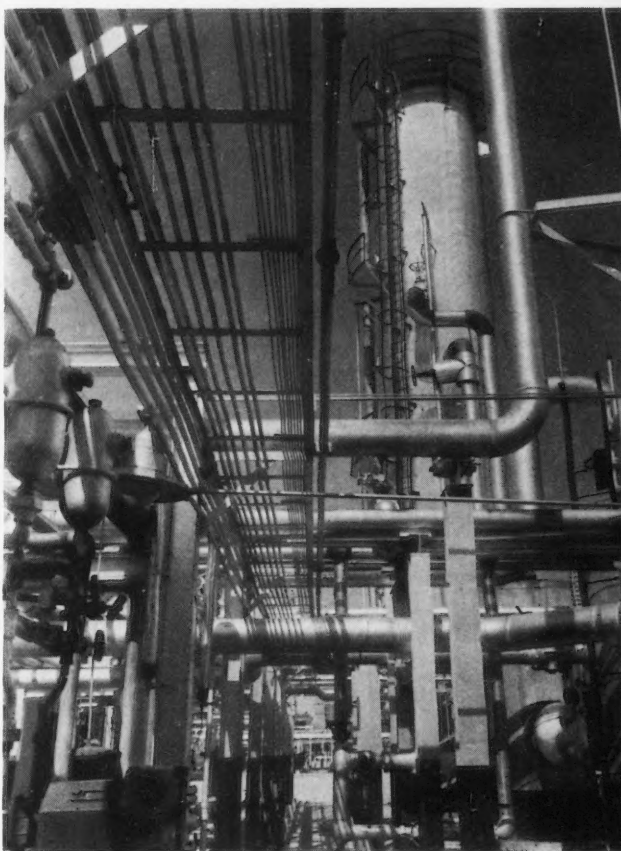


Figure 3—View in a modern gasoline plant. Aluminum instrument lines and coverings for thermal insulation are shown.

vides the optimum combination of strength, formability, endurance limit and resistance to corrosion. It can safely handle the pressures customarily encountered in instrument air service and has excellent bending and flaring characteristics. The endurance limit is comparable to that of annealed copper and is significantly higher than that of 3S-O aluminum alloy. Because it is stronger than 3S-O, B50S-O alloy has a better "feel" when fittings are tightened; the

(Continued on Page 2)

Aluminum Coiled Tube—

(Continued From Page 1)

possibility that flares will be cut off is, therefore, minimized.

Because aluminum alloys have been shown to have high resistance to corrosion in atmospheres containing hydrogen sulfide and sulfur dioxide, the superiority of aluminum instrument tubing was recognized early by gas and oil processing plants. Results over the last few years have demonstrated the wisdom of using aluminum in such plants. The resistance of aluminum alloys to atmospheres containing sulfurous gases and products of combustion is also well demonstrated by their performance in industrial atmospheres. Figure 1 shows the results of test carried out on carbon steel and aluminum in two industrial atmospheres. It also shows the results of similar tests in seacoast exposures. Even in many atmospheres where high humidity and industrial pollution exist, aluminum can perform well, if provision for free-air circulation is made.

Two of the many installations of aluminum instrument tubing are shown in Figures 2 and 3. Literally millions of feet of this tube have been installed in instrument air service and each year finds the list of installations increasing.

A smaller amount of aluminum tube has been used for steam tracing lines and has been found perfectly suitable for dry steam below 400 degrees F which is free of entrained alkaline boiler compounds, providing the steam velocity is such that erosion will not occur.

Installation technique for aluminum tubing systems is simple and straightforward. Best practice calls for elimination of contacts between aluminum and dissimilar metals, particularly copper and copper alloys. Such contacts in the presence of an electrolyte can cause galvanic corrosion of the aluminum. Conventional steel supports for tube lines can be used but they should be painted, preferably with a zinc-

chromate primer followed by two coats of high-quality aluminum paint. The use of a strip of aluminum between the tubes and the support is also recommended. Clips can be either of aluminum or galvanized steel. Stretch straightening of coils is practical, but over stretching should be avoided.

Aluminum tube fittings are definitely recommended for use with aluminum tube and these are available from several fitting manufacturers, usually at prices closely comparable with those of brass fittings of the same type. Aluminum fittings have been successfully used in contact with brass instrument parts as this joint is usually dry; however, if dampness exists the mass of the fitting will usually be sufficient to minimize trouble.

Contact with some insulation materials may cause corrosion of the aluminum, especially if the insulation is wet. If contact between aluminum and insulation material is expected, the best choice of insulation would be one of the borosilicate glass products which are available in several forms. Some of the other insulating materials can stimulate corrosion of the aluminum under moist conditions to a larger degree than that which would be expected if the glass insulation were used.

The aluminum tube should be installed so as to be protected as much as possible against the collection of debris, etc., on the upper surface to prevent the occurrence of chemical attack or concentration-cell corrosion under moist conditions. Supports which permit good drainage and free-air circulation are much preferred to the continuous trough types which are of poor design from a corrosion viewpoint because of their tendency to collect and retain moisture. The observance of these practices will permit aluminum tube to provide the long trouble-free life of which it is capable.



NACE News

Southern New England Section Is Organized

Interim Executive Is Appointed for Canada

An interim executive for Canadian Region to function until permanent officers can be elected has been named as follows: G. I. Russell, Union Gas Co. of Canada, Ltd., chairman; L. W. Shemilt, University of British Columbia, vice-chairman; W. F. Croft, Kopper's Products, Ltd., membership chairman and G. M. McPherson, Imperial Oil, Ltd., secretary-treasurer. A nominating committee for permanent region officers is being selected.

Plans have been made for a meeting of Canadian members of NACE during the Ninth Annual Conference at Chicago in March. This meeting, to be held probably in connection with a luncheon or dinner, is expected to bring together members in this new subdivision of the association so plans can be made for further activity.

Philadelphia Section Elects Brink, Hears Luce on High Alloys

Officers for Philadelphia Section for 1953 were elected December 12 as follows: E. G. Brink, American Viscose Co., Marcus Hook, Pa., chairman; H. H. Bennett, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J., vice-chairman; J. S. Pettibone, American Society for Testing Materials, Philadelphia, re-elected secretary-treasurer.

Walter A. Luce, Duriron Company, Dayton, Ohio, who spoke on "Stainless Steel and Other High Alloys," said stainless steel and cast iron are the two materials most widely used for handling acids at moderate temperatures. Tests are being made to explain their corrosion behavior.

Titanium, which behaves much the same as stainless steel in dilute hydrochloric acid, has high resistance to corrosion in sea water but is unsatisfactory in sulfuric acid, he said.

Intergranular corrosion occurs in 16 percent chrome stainless steel alloys at 800 degrees F when chromium carbides precipitate at grain boundaries, but this can be overcome by water quenching at 2000 degrees F. Stabilizers, such as columbium or titanium can be used when quenching is impractical, but columbium's use is restricted by priority regulations. Typical intergranular corrosion is seen in the welds of drums that handle nitric acid, because the welded metal is



NACE MEETINGS CALENDAR

Feb.

- 5—Pittsburgh Section. Corrosion in Heat Exchangers, by John J. B. Rutherford, Babcock & Wilcox Tube Co., Beaver Falls, Pa.
- 10—Houston Section. Stress Corrosion Cracking of Stainless Steels by S. E. Doughty, Carpenter Steel Co.
- 13—Philadelphia Section. Corrosion Inhibitors by Paul Cardwell, Dowell, Inc.
- 17—Chicago Section. Round Table Discussion on Protective Coatings.
- 17—Cleveland Section. Corrosion of Iron and Steel, by R. B. Hoxeng, United States Steel Company, Pittsburgh.

March

- 3—Houston Section. Joint meeting with ASM. Frank LaQue, speaker.
- 5—Pittsburgh Section. Corrosion of Water Mains and Water Distribution Systems, speaker to be named.
- 17—Cleveland Section. The Use of Plastics in Corrosive Environments, speaker to be named.
- 31—Southwestern Ohio. Protective Coatings, C. G. Munger, Amercoat Corp.

sensitized by high temperatures created by the welding.

Other Intergranular Corrosion

Intergranular corrosion occurs also in the manufacture of pump casing when the main body of the cover is cast and the flange welded. Metal adjacent to the weld will appear gouged out when the cover is subjected to furnace temperatures. This difficulty is solved by using Ni-resist, molybdenum or molybdenum with chrome.

Steel with a carbon content of 0.03 percent passed the 60 percent boiling nitric acid test, but titanium failed because of the formation of a sigma phase which lowers resistance to corrosion.

Improvements Sought

The Alloy Casting Institute, recently formed, is seeking to develop improved stainless steel and cast iron compositions for the chemical industry. A code for cast iron, similar to and correlated with existing stainless steel codes has been adopted by the institute and the American Society for Testing Materials.

The current problem is to determine what casting alloys are safe for use with acids above the boiling point. While copper has been found to greatly retard corrosion, the only satisfactory

F. R. Meyer of Southern New England Telephone Company, New Haven, Conn., was selected first chairman of the recently organized Southern New England Section of NACE. Also elected were A. W. Tracy, American Brass Company, Waterbury, Conn. vice-chairman and F. M. Barry, Scovill Manufacturing Co., Waterbury, secretary-treasurer. The election was held January 5 at New Haven.

Committee heads were named as follows: L. M. Rasmussen, Manning, Maxwell & Moore, Stratford, Conn., social; A. M. Plant, United Illuminating Co., New Haven and Archer Hamilton, Hartford Gas Co., Stamford, membership; J. M. Johnquest, Bristol Co., Waterbury, Conn., publicity and Arthur T. Steeves, Electric Boat Co., Waterbury, reception.

First regular technical meeting is scheduled February 4 for a showing of the Inco film "Corrosion in Action" with T. P. May of International Nickel Co., to conduct a discussion. Meetings are scheduled also for first Wednesdays of April, June, October and December, the place to be determined by membership vote at preceding meetings.

Best Heads Region

George E. Best, Mutual Chemical Co., Baltimore, has been elected chairman of North East Region NACE. Also elected were Kempton H. Roll, Lead Industries Association, New York, vice-chairman and W. R. Briggs, Briggs Bitumen Co., Philadelphia, Secretary-treasurer. They took office January 1.

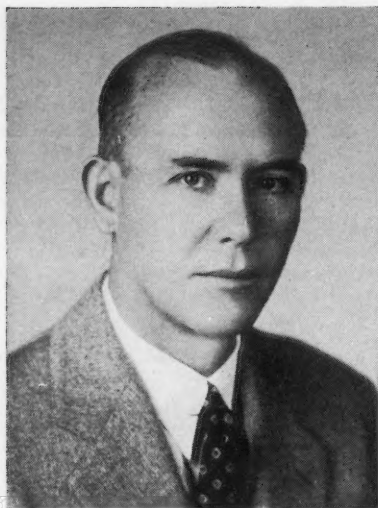
Von Lossberg Is Elected

L. G. Von Lossberg, Sheppard T. Powell Consulting Chemical Engineers, has been named chairman of Baltimore Section. Also elected were Allen L. Alexander, Naval Research Laboratory, vice-chairman and Risque Benedict, Naval Research Laboratory, secretary-treasurer.

remedy so far developed has been the use of inhibitors.

Among stabilizer columbium is the best, while titanium is extremely reactive and the final results cannot be guaranteed. The quality of castings may be improved by the use of selenium, use of the oxygen lance when casting scrap steel and by using virgin metal of high purity. High purity is the only means of holding carbon content at 0.03 percent, but causes enormous waste and high costs, Mr. Luce said.

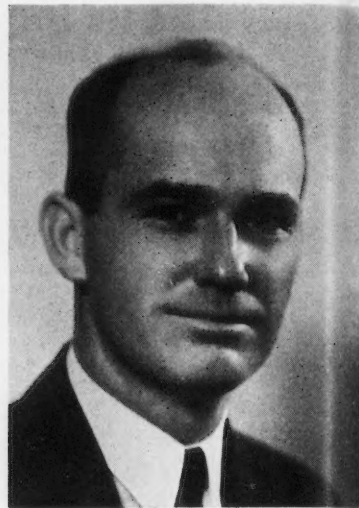
The Inter-Society Corrosion Committee was organized to help eliminate duplicated research into corrosion matters.



WALTER F. ROGERS
Gulf Oil Corp., Houston, president-elect.



AARON WACHTER
Shell Development Company, Emeryville, Cal., vice-president elect.



RUSSELL A. BRANNON
Humble Pipe Line Co., Houston, incumbent and treasurer-elect.

New NACE Officers Will Take Over on March 20

Kansas City Section Officers Nominated

Officers were nominated at an organization meeting of Kansas City Section January 9 at Phillips Hotel, Kansas City. Nominated were L. F. Heverly, Great Lakes Pipe Line Co., chairman; R. A. Kelley, Minnesota Mining & Mfg. Co., vice-president and J. C. Berringer, Panhandle Eastern Pipe Line Company, secretary-treasurer. Election of officers will be held at a February 9 meeting.

Present for the dinner meeting were F. L. Whitney, Jr., North Central Region Director, who explained procedure for organizing a local section and discussed the operation of a section; Walter F. Rogers, NACE president-elect and A. B. Campbell, executive secretary of NACE who discussed association matters in answer to questions asked.

There were 20 present for the meeting. A letter from Jack H. LoPrete, North Central Region Chairman in which the request for a section was approved, was read.

The 1954 NACE Conference will be held at Kansas City.

Olive New Chairman Of Shreveport Section

M. J. Olive has been elected chairman of Shreveport Section for 1953. Mr. Olive is with Arkansas Natural Gas Corp. Other officers elected to serve during the year were W. F. Levert, United Gas Pipe Line Company, vice-chairman; J. O. Griffin, Texas Eastern Transmission Co., treasurer; A. W. Wheeler, Graybar Electric Co., secretary and H. V. Beezley, United Gas Pipe Line Co., trustee.

The January 14 meeting, scheduled to be held jointly with the American Petroleum Institute, was to hear K. W. Robbins of Otis Pressure Control, Inc.

S. E. Region to Meet

The spring 1953 meeting of South East Region has been scheduled for May 7 at Hotel Patton, Chattanooga, Tenn. D. F. Joyce, of Combustion Engineering, Chattanooga, will be program chairman.

Jack Battle Elected Tulsa Section Head

Tulsa Section will hold its annual Corrosion School March 4-6 in Tulsa, according to arrangements announced by William A. Hutchison, of Sinclair Pipe Line Company. This announcement and the names of new section officers were given at a Tulsa Section dinner meeting December 23 at Michaelis Cafeteria attended by 27 members.

New officers are Jack P. Barrett, Stanolind Oil & Gas Co., chairman; Lloyd Nelson, Shell Pipe Line Co., vice-chairman; Hugh A. Brady, Pipe Line Anode Corp., secretary and Edward A. Bartolina, Moorlane Company, treasurer. J. N. Hunter, Jr., Service Pipe Line Co., outgoing chairman was named trustee.

After the business meeting a color motion picture "Duck Hunting" was shown.

Teche Sees Inco Film

Teche Section NACE and the Lafayette Engineering Society at a joint meeting December 9 witnessed the International Nickel Co. film "Corrosion in Action." The meeting was held at the Southwestern Louisiana Institute Training School Auditorium, Lafayette. Allen Bonnet, president of the engineering society called the meeting to order and turned it over to Gus Vogler, section vice-chairman for presentation of the film.

Officers for 1953-54 who will take over the management of the affairs of the National Association of Corrosion Engineers on the last day of the 1953 conference at Chicago are:

Walter F. Rogers, Gulf Oil Corp., Houston, president. Mr. Rogers was vice-president in 1952-53.

Aaron Wachter, Shell Development Company, Emeryville, Cal., vice-president. Mr. Wachter, long active in the association and formerly a director representing active membership, is a frequent contributor of technical material on corrosion.

Russell A. Brannon of Humble Pipe Line Company, Houston, has been re-elected.

Also elected were W. F. Fair, Jr., Tar Products Division, Koppers Company, Inc., Westfield, N. J., and Robert L. Bullock, Interstate Oil Pipe Line Company, Shreveport, La., director, representing active members and J. Pat Casey, Jr., The Crane Company, Chicago, director representing corporate members.

Tellers counted 1825 valid ballots.

British Seek Speaker On Cathodic Protection

The Corrosion Group of the British Society of Chemical Industries has invited the National Association of Corrosion Engineers to participate in its projected one day meeting on cathodic protection at London during November, 1953. Walter F. Rogers, president-designate of the association has requested that any member of NACE who expects to be in London then and who will prepare a paper on this subject for delivery at the meeting communicate with A. B. Campbell, executive secretary of the association.

The Corrosion Group expects to have six papers on cathodic protection and has expressed a preference for a paper discussing experience in the United States in electrically protecting buried structures.

Spa
N. T.

J. C.
North
lowing
dinner
tion at
phone,
and A.
Membr
Kenner
H.
Water
hind t
problem
of 500,
was co
J. M.
telepho
related
first in
in 1923
North
day mo
ing da
Dallas.

San
Nam

New
Franci
G. A.
of Cal
D. R.
Califo
and T.
Co., Sa
treasur

co

Mar. 3
Body
Mich
paper

Mar. 16
hibit
rosion
Hote

Apr. 1
ciety
Statl

Apr. 13
Distr
rosion
Hote

May 10
social
Rapi
rosion

May 11
ican
Corro

June 4
Meeti
of Ca
June 15
Societ
Benja

pers
July 20
Confe
don, J
August
sociat

Spalding Names New N. Texas Committee

J. C. Spalding, Jr. new chairman of North Texas Section appointed the following committees at the January 5 dinner and business meeting of the section at Venus Restaurant, Dallas: Telephone, Gene Greenwell; Entertainment and Arrangements, Charles Slover; Membership, H. L. Bilhartz; Publicity, Kenneth Robbins.

H. G. Graeser, of the Dallas City Waterworks presented a discussion "Behind the Water Faucet" in which the problems encountered in supplying a city of 500,000 with safe, non-corrosive water was covered.

J. B. Bolmberg, retired from the telephone company, present as a guest, related his experience with one of the first installations of cathodic protection in 1923.

North Texas Section meets first Monday monthly and tries to alternate meeting dates between Fort Worth and Dallas.

San Francisco Section Names New Officers

New officers have been named by San Francisco Bay Area Section as follows: G. A. Works, Jr., Union Oil Company of California, Oleum, Cal., chairman; D. R. Loper, Standard Oil Company of California, San Francisco, vice-chairman; and T. J. Smith, Electric Steel Foundry Co., San Francisco, re-elected secretary-treasurer.

Inter Society Committee CORROSION MEETINGS CALENDAR

Mar. 3-5—SAE National Passenger Car, Body and Materials Meetings, Detroit, Mich. Hotel Sheraton-Cadillac. (Some papers on automobile corrosion.)

Mar. 16-20—Annual Conference and Exhibition, National Association of Corrosion Engineers, Chicago. Sherman Hotel.

Apr. 12-16—The Electro-chemical Society, Spring Meeting, New York City. Statler Hotel.

Apr. 13-16—American Gas Association—Distribution, Motor Vehicles and Corrosion Conference, Chicago. Sherman Hotel.

May 10-15—American Water Works Association—General Convention, Grand Rapids, Mich. (Two papers on corrosion control.)

May 11-14—Midyear Meeting of American Petroleum Institute, Session on Corrosion of Refinery Equipment, New York, N. Y. Commodore Hotel.

June 4-6—Protective Coatings Division Meeting, Annual Chemical Institute of Canada Conference, Windsor, Ont.

June 15-18—American Electroplaters Society, Annual Meeting, Philadelphia. Benjamin Franklin Hotel. (Some papers on corrosion.)

July 20-25—AAAS Gordon Research Conference on Corrosion, New London, N. H.

August—Symposium on Corrosion, Association Committee on Corrosion Re-

search and Prevention of National Research Council of Canada.

Sept. 13-17—The Electro-chemical Society, Fall Meeting, Wrightsville Beach, N. C., Ocean Terrace Hotel.

TP-1D Reprints Made

Reprints of a report by Technical Practices Committee 1-D on Sour Oil Well Corrosion by J. A. Caldwell, as published in *CORROSION*, August, 1952, are available from Central Office NACE. The cost is 50 cents per copy postpaid. This report was published in *CORROSION*, Vol. 8, No. 8, 292-294 (1952) Aug.

Persons interested in joining NACE may get information and application blanks for membership by writing to Central Office, 1061 M & M Building, Houston 2, Texas.

New TP Committee On Plastics Is Formed

A technical practices subcommittee to TP-1 on Corrosion of Oil and Gas Well Equipment has been organized to study structural plastics. The subcommittee, designated TP-1J on Oil Field Structural Plastics, has W. M. Thornton of Atlantic Refining Co., Dallas, as chairman and B. W. Bradley, Shell Oil Company, Tulsa, as vice-chairman.

The growing use of plastics in oil field operations created the need for the committee which will study the merits of the various materials available.

Paid circulation of *Corrosion* has increased every year since the magazine was founded.



time will tell . . .

but not on
**Reilly
Enamels**

Reilly Enamels are manufactured under rigid control from carefully selected raw materials which include high temperature coal tar, suitable fluxes and mineral filler. Reilly Enamels stand the test of time because their tough abrasion resistant films withstand fresh or salt water, in acid and alkaline soils.



REILLY TAR & CHEMICAL CORPORATION

MERCHANTS BANK BUILDING

INDIANAPOLIS 4, INDIANA



149 Register for Western Region Meeting at Los Angeles Biltmore

Eight discussions on corrosion problems and the way in which industry is solving them were featured on the technical program at the November 20-21 meeting of Western Region. Registration of NACE members and guests at the Los Angeles Biltmore was 149.

The region's board of trustees met during the morning of the 20th and received the petition from NACE members in the San Diego section for organization of a section there. The board accepted the petition and the members are now engaged in perfecting the local organization.

W. M. Schilling, regional chairman, opened the meeting in the Renaissance Room of the Biltmore at 10:30 am on the twentieth with the International Nickel Co., Inc. film, "Corrosion in Action." The showing of the film was followed by a review of the functions of the NACE Technical Practices Committee, by L. L. Whiteneck, Western Region director and A. B. Campbell, NACE executive secretary.

After lunch Guy Corfield, afternoon chairman, introduced Norman Hackerman, of the University of Texas, who spoke on the fundamentals of corrosion and I. E. Boberg of Chicago Bridge and Iron Company, who spoke on "Effect of Corrosion on Steel Structure Design."

From 5 to 6:30 pm the manufacturers' "Fellowship Hour" was held. Members and guests were introduced and speakers were bombarded with questions.

A half-hour's entertainment followed dinner, and a color film of the 1952 Olympics was shown.

Chairman E. H. Grizzard Friday morning introduced E. N. Frisius,

Magna Products Inc. who spoke on "Control of Oil Well Corrosion."

E. H. Tandy, Standard Oil Co. of California, the next speaker, discussed "Refinery Corrosion Problems." He was followed by Pierre Van Rysselberghe of the University of Oregon who spoke on "Recent Developments in European Corrosion Research." Mr. Van Rysselberghe recently returned from Europe.

After lunch Guy Corfield introduced Carl J. Christensen of the University of Utah, who spoke on "Corrosion in Stone and Masonry." C. G. Munger of Amercoat Corporation, talked on "Plastic Coatings for Corrosion Problems," outlining the way the development of modern industry creates a demand for high performance protective coatings. H. A. Humble, manager of Cathodic Protection Sales, Dow Chemical Company, the last speaker, talked on "Current Applied Research in Cathodic Protection."

Preventive Inspection Urged as Means of Corrosion Mitigation

Years ago when the refining of crude oil was rather a simple process inspection often consisted of waiting for a leak to show up and then shutting down the equipment involved for repairs. Now, however, Edward H. Tandy of Standard Oil Company of California, said "a modern refinery's equipment and processes are much more complicated and the failure of a minor part might shut down

AT WESTERN REGION MEETING—A group at the Western Region Meeting November 20-21 at the Los Angeles Biltmore, left to right: Back row, Guy Corfield, John R. Brown, E. H. Grizzard, M. L. Michaud, Austin S. Joy; front row, Robert H. Kerr, Flora Lombardo, W. M. Schilling, L. L. Whiteneck. Mr. Corfield was program chairman. Mr. Grizzard was Friday program chairman. Messrs. Brown, Joy and Michaud were members of the publicity committee; Mr. Kerr was in charge of registration. Mr. Schilling is region director, Mr. Whiteneck was region chairman. Miss Lombardo was region secretary-treasurer.

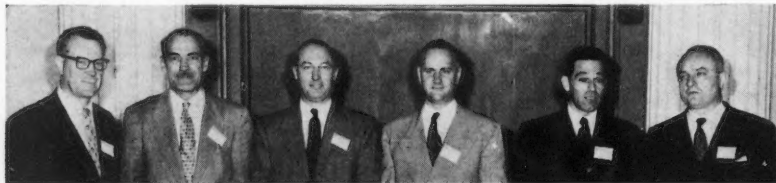
an entire plant." There have been some instances in refineries where fires resulting from minor failures have almost completely destroyed an entire plant, he said.

Mr. Tandy spoke to an audience of corrosion engineers at the Western Region NACE meeting at Hotel Biltmore, Los Angeles, November 21.

The speaker enumerated cases of corrosion damage in his own experience and gave causes and told of the remedies adopted. He emphasized the need for a systematic and intelligent inspection system in which data on the condition of equipment was continuously evaluated with respect to changes in crude, speed or pressure, temperature and changes in equipment. His company has an Equipment Inspection Section as a part of the refinery Engineering Division, Mr. Tandy said. The inspectors must have a fundamental knowledge of the chemistry of the processes and operating conditions of the plants he inspects as well as an intimate knowledge of the individual pieces of equipment. Increased use of heat and corrosion resistant alloys requires an understanding of practical metallurgy also.

Four basic points to be considered in evaluating refinery corrosion problems were given by Mr. Tandy as:

1. Can the corrosive material be eliminated before it gets to the point where it does the damage?
2. Can operating conditions be adjusted to eliminate or minimize corrosion?
3. Can the equipment be protected by some corrosion-resistant material or cathodic protection?
4. If the equipment must be replaced is the design adequate?



SPEAKERS AT WESTERN REGION MEETING—Left to right, Carl J. Christensen, University of Utah; E. H. Tandy, Head, Equipment Inspection, Standard Oil Co. of California El Segundo Refinery; C. G. Munger, Technical Director, The Amercoat Corp.; E. N. Frisius, Magna Products Inc.; Norman Hackerman, University of Texas; Pierre van Rysselberghe, University of Oregon.

Reprints of technical material printed in Corrosion are not made except on special order. A limited number of reprints of especially interesting material is made on occasion.



News about COATINGS for METALS

Metallic Organic Decorative Protective

Using an Engineering Approach in Plant Painting Cuts Maintenance Costs — Corrosion, too

Porosity no problem with Plastisol protection

In a recent test of many coatings for use in refrigeration equipment, only a Unichrome Plastisol Coating withstood 1500 hours of water immersion. All other coatings tested by the user failed because of porosity.

This case emphasizes why Unichrome Plastisols, which build up a film thickness of from 3 mils to 3/16-inch as desired, give such extraordinary protection to ordinary metals in contact with a wide variety of corrosives. The chemicals don't penetrate this heavy duty coating to attack the metal. Nor do they attack the coating itself since it is a vinyl formulation.

If you need an exceptional protective material for processing equipment, investigate a Unichrome Plastisol Compound.

Improved phenolic-type lining for drums

Phenolic coatings are the dependable "workhorse" of the drum lining industry. They have long been favored by packaging engineers for use in steel containers to protect the package from corrosion and the contents from contamination.

Unichrome Series B-124 Linings have been acknowledged by many users to be outstanding improvements in this type of material. They bake into extremely tough and durable linings that have excellent adhesion and unusual ability to withstand strong acids, oils, food chemicals, vinegar, wetting agents. Solvents such as benzene and ketones also have no effect on B-124 linings.

Other linings also available for other products. Write for data, and for information on manufacturers and reconditioners supplying drums with Unichrome Drum Linings.

Coatings have definitely become important materials of construction to the chemical or corrosion engineer. With many types of coating materials available to meet unusual requirements, no longer is surface protection being classed as merely another paint job. Instead, many plants are thinking of maintenance painting as an engineering problem, to be solved by an engineering approach.

Such an approach can make a big difference in results — both in longer lasting equipment and more durable paint jobs.

AN ENGINEERED PAINTING PROGRAM

Engineering a solution to a painting problem means devoting proper attention to surface preparation for the coatings which are to be applied. It means specifying a system or combination of coatings devised for the service conditions encountered.

ADEQUATE SURFACE PREPARATION

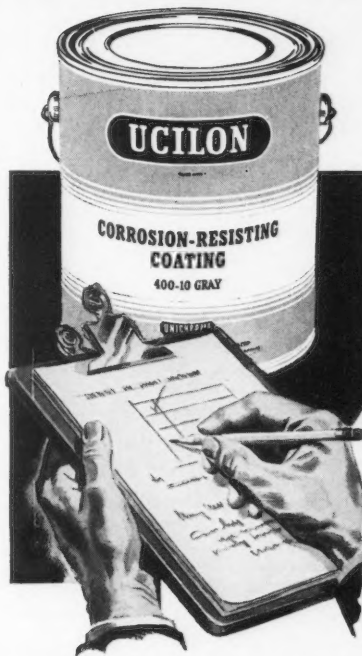
Generally, the tougher the corrosion problem, the more attention the surface needs. Sometimes this includes careful mechanical preparation. Experience has shown that, when required, one of the most important steps is also priming. This contributes to better adhesion of subsequent top coats. It adds extra corrosion resistance and minimizes undercutting of the protective film in the event of a break in its continuity.

Ucilon Coating Systems include proved materials for use in priming wherever individual applications require them. These include chromate-type primers, wash primers, intercoats.

CORROSION PROBLEMS SOLVED

Systems of Ucilon Coatings form effective barriers to a hundred and one tough, corrosive conditions. Many such systems are available to permit the engineer to specify a material that protects against intermittent or continuous contact with acids, alkalies, salt solutions, alcohols, moisture, oils, chemical compounds and other products.

Protection provided by Ucilon Coatings is based on vinyl, chlorinated rub-



ber, phenolic or fish oil formulations and the degrees of chemical resistance that such materials possess. Some coatings require baking. Most dry by solvent evaporation or by oxidation.

"AN OUNCE OF PREVENTION"

Preventive maintenance was always a good idea. Today it can be considered virtually vital in order to end needless corrosion of equipment and avoid the production delays, costly downtime and replacement headaches that such damage entails. Ucilon Coatings Systems can help you achieve longer lasting protection at lower cost and make your preventive maintenance more effective.

Be sure to look up the concise facts on Ucilon Coatings in your latest "C.E.C." Or write for bulletin No. MC-6.

UNITED CHROMIUM, INCORPORATED
100 East 42nd Street, New York 17, N. Y.
Detroit 20, Mich. • Waterbury 20, Conn.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto, Ont.

European Corrosion Research Described

European corrosion research has a pronounced tendency to base itself more and more on fundamental physical chemistry and electrochemistry, Pierre Van Rysselberghe, of the Department of Chemistry, University of Oregon, told persons attending the NACE Western Region meeting at Los Angeles November 21. This tendency exists in both university and industrial and commercial laboratories, he said. The speaker cited the following examples of European research activities:

University of Cambridge, England—Experiments demonstrating film formation at high current density involving the use of mercury droplets and a copper electrode. At low current densities mercury wet the copper, but at high densities bounced off, indicating formation of a film on the copper. A periodicity has been observed in electrochemical phenomena and studies in the physiological field also reveal a periodicity. An attempt is being made to relate the two.

Switzerland—Less fundamental work appears to be underway than in Germany although investigation and identification of corrosion products is getting some attention.

Italy—There is a close relationship between academic and industrial research and there are an unusually large number of scientific magazines, even some published by large industries.

The studies of R. Piontelli at the University of Milan in plotting crystal orientation and polarization curves for metal deposition and solution are noteworthy. Emphasis is being placed on overvoltages so small they are difficult to detect.

France—Routine test methods such as salt spray and immersion are being abandoned in favor of polarization curves and theoretical electrochemical studies which provide the information more

reliably and rapidly. Stainless steel research is being stressed and other work is being done on the relationships between electrochemical potentials and polishing.

Spain—Government-sponsored research is under way. At the University of Madrid investigations start with thermodynamics and conclude with polarization curves. Many scientific magazines are published.

Iron Curtain—The theoretical freedom of access to corrosion research data by French and Italian Communists behind the Iron Curtain has produced nothing "more stimulating, if not entirely pleasant, than exercise."

Belgium—Pierre Pourbaix, at the University of Brussels, stimulated by U. R. Evans' studies on the effects of the three variables, current, potential and pH has been producing curves demonstrating the corrosion behavior of metals in reversible equilibria with their ions.

Corrosives' Effect On Stone Revealed

The effect of several corrosives on building stones was described by Carl J. Christensen of the University of Utah to registrants at the NACE Western Region meeting at Los Angeles November 21. Dr. Christensen enumerated the mechanical disintegration properties of some principal types of building stones and gave four precautions in choosing masonry:

1. Choose the stone suited to the environment.
2. Exclude salts.
3. Try to keep dry.
4. Provide for drainage of water.
5. Keep surface clean but never wash with strong alkali.

Calcite (marble), quartz and granite are anisotropic or temperature sensitive. Marble subjected to high hydrostatic pressure underground will flow, and crystalline distortions will cause cracking, Dr. Christensen said.

Stones with large crystals are more

subject to cracking from temperature changes than those with small ones, and a sort of EMF table for stone types has been prepared with stones arranged according to their acidity. Electron hungry silica is on the extreme acid side and calcite on the highly basic side.

Limestone, a basic material, is readily attacked by acid gases, and when it is mistakenly washed with strong alkali in the presence of a corrosive atmosphere Na_2SO_4 is produced which is highly water hungry. This frequently causes cracking, the speaker said. Furthermore imbedded iron is dangerous because of the large volumetric difference between iron and iron oxide. Even the application of salt has been known to cause limestone to crack, he said.

Maintenance Costs Reduced By Inhibitors

Through the use of inhibitors up to 75 percent of the maintenance costs in some oil wells located in California has been saved. E. N. Frisius, of Magna Products, Inc., speaking to registrants at the NACE Western Region meeting November 21, based his statement on the cost records from 57 representative wells from three fields. His data were broken down to show savings in pumps, tubing, rods, rod boxes, well pulling and crew hours for a year. Mr. Frisius attributes much of the remaining maintenance to failure of equipment damaged before inhibitor treatment was started.

Documented with data from Huntington State Company's "slanting" oil wells, which tap oil beneath the sea he listed savings by the well by quarters and in the aggregate. Net saving per well per quarter ranged from \$488 to \$1275. Service in these slanted wells is especially severe because the sucker rods and rod boxes rub constantly on the lower side of tubing.

Mr. Frisius emphasized a corrosion control program must include a study of each well individually.

New Plastic Materials Help Reduce Corrosion

Increasingly severe corrosive environments developed as a result of modern industrial processes have fostered the evolution of a whole new family of materials, the plastics, now being used extensively to supplant conventional paints. C. G. Munger of Amercoat Corporation told an audience at the NACE Western Region meeting November 21 at Los Angeles. The tough films formed by these materials, while they require special care in application to get bond, have proved the answer to many difficult corrosion problems, he said.

Mr. Munger explained the characteristics of the principal plastic material now available, and told of application methods, emphasizing the importance of adhesion, coating thickness and vapor transmission rate. He gave examples of the use of the plastics in severely corrosive environments, including atomic energy installations, offshore oil wells, ammonium nitrate plants, rayon plants, the food industry, paper manufacture and in the lining of water tanks and equipment. The successful use of plastic coatings on marine equipment and in protecting concrete sewer pipe from damage from hydrogen sulfide by products also was explained.

Gives you a quick, easy method of determining what metal alloys to use in connection with 143 different corrosive agents. Ideal for metallurgists, product designers, engineers, chemists, purchasing agents. Sized to fit your pocket. Developed by The H. M. Harper Co., America's leading specialist in non-ferrous and stainless fastenings.

**FREE
MAIL COUPON TODAY!**

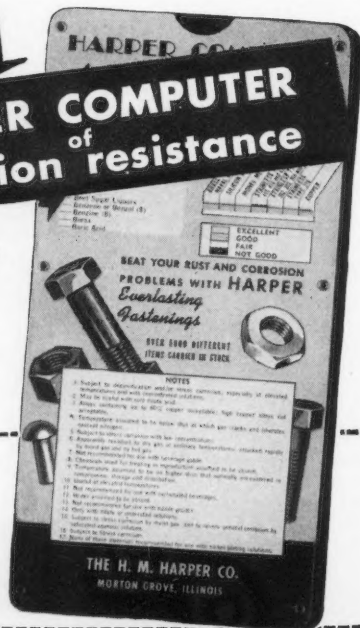
Chief Metallurgist,
The H. M. Harper Co.,
8221 Lehigh Avenue, Morton Grove, Ill.

Please rush my free copy of the Harper Computer of Corrosion Resistance.

Name.....
Company.....
Address.....
City.....State.....

SEND FOR
YOURS TODAY!

HARPER COMPUTER
of
corrosion resistance



Condenser Tube Alloys Discussed at Houston

A. W. Tracy of American Brass Company discussed "Condenser Tube Alloys" at a January 13 dinner meeting of Houston Section. The 77 members and guests present participated in the usual floor discussion following Mr. Tracy's remarks and witnessed a motion picture film on copper mining.

During a short business session candidates for section offices for the coming year were nominated and a letter was read from the Houston Paint and Varnish Production Club sounding out the section's views on possible closer cooperation between the two groups in solving mutual problems on a local level.

American Brass Company was host at a social hour preceding the meeting.

Engineers' Council's Report Is Published

The Engineers' Council for Professional Development, an organization composed of various engineering societies, has published its Twentieth Annual Report.

Chief among the accomplishments of the organization during 1952, according to L. F. Grant, chairman of the organization has been in the development of activities for high school boys who are interested in entering engineering professions. Purpose of the committee in charge of this work is to provide an organization from which any boy in the United States and Canada, who is interested, can obtain sound information on such points as the academic demands on his ability, his prospects in the profession, the universities offering engineering curricula in his locality and other pertinent facts. It is hoped that this will help to alleviate the shortage in engineers.

Another prime objective of the organization is to institute a training program for young engineers. This project is under the guidance of professor Wandmacher, head of the department of civil engineering, University of Cincinnati.

The organization also has published a report on "Adequacy and Standards of Engineering Education."

British Industries Fair To Be Held Apr. 27-May 8

Nearly 100 different industries will be represented at the British Industries Fair scheduled for London and Birmingham, England from April 27 to May 8, 1953. Displays by 2500 exhibitors will be arranged in 30 groups of allied trades. The exhibits will be divided among three locations. The heavy industry display will be held at the giant exhibition hall at Castle Bromwich, Birmingham and consumer goods will be shown at Olympia and at Earls Court in London.

Fontana to Speak

Mars G. Fontana, NACE president, will address Detroit Section February 19 on the subject "Corrosion and Its Prevention." The dinner meeting will be held jointly with the Electrochemical Society at the Engineering Society of Detroit. Affiliated technical societies also have been invited to attend.

Spectrographers Seek Papers for Symposium

The American Association of Spectrographers is planning a symposium on "Emission Spectroscopic Determination of Metals in Non-Metallic Samples." The

symposium will be held in Chicago, Ill., on May 1, 1953.

Contributed papers are welcome. Address J. Pagliassotti, chairman symposium committee, Standard Oil Co., Box 431, Whiting, Ind.

Tool Engineers Set Meeting at New York

Increased productivity and cost reduction will be emphasized in the technical sessions at the 21st Annual Meeting of the 23,000-member American Society of Tool Engineers to be held in Detroit, Mich., at the Hotel Statler, March 17 to 20. The 21-paper technical program will cover many new fields in which tool engineers are now actively engaged, spokesmen said.

Is a specialist in LEAD PRODUCTS

really a better supplier for YOU?

There is a theory that a man who specializes in mousetraps will build better mousetraps than one who makes merely wood or metal products. This is the narrow view of the self-conscious specialist.

Others say, "Specialists are those who know more and more about less and less," which invites the conclusion that the greatest specialist of all must be he who knows everything about nothing.

Federated believes that the hundreds of products of non-ferrous origin have a basic family resemblance, and that the more we know about all, the more we know about each. Thus lead is found with silver and antimony, and copper and tin are found with iron. These various elements and others must be separated and refined, or in some cases, discarded. Then, re-combined in different ways, sometimes alone, sometimes with other non-ferrous ingredients, they make brass, bronze and aluminum ingot; solders and type metals; die casting alloys, lead products and bearing metals; anodes for plating and for cathodic protection.

Federated's competent organization of scientists and technicians, and its widespread field force of servicemen, are unified under the central policy of producing quality products and making these products most useful to every Federated customer from the one-man shop to the largest plant in the country.

We count it an advantage to our customers that Federated's organization is big enough to specialize in quality control and service from the depths of the mine to the user's shop.

It is one of the reasons that Federated is known as "Headquarters for Non-ferrous Metals."

Federated Metals Division

AMERICAN SMELTING AND REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.

In Canada: Federated Metals Canada, Ltd., Toronto, Montreal



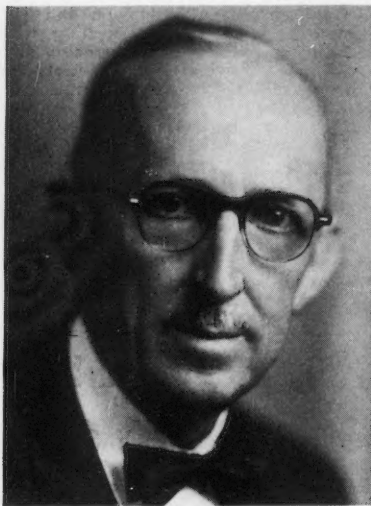
Aluminum and Magnesium, Babbitts, Brasses and Bronzes, Anodes, Die Casting Metals, Lead and Lead Products, Solders, Type Metals

Ewing and Burns to Receive Awards for 1953



SCOTT P. EWING

Carter Oil Company, to receive the 1953 Speller award.



R. M. BURNS

Bell Telephone Laboratories, to receive the 1953 Whitney Award.

Presentation Will Be Made at Annual Banquet at Chicago

The 1953 Speller and Whitney Awards will be made at Chicago to Scott P. Ewing and Robert M. Burns, respectively. Mr. Ewing, corrosion engineer with the Carter Oil Company, Tulsa, Oklahoma and Mr. Burns, chemical coordinator and director of chemical and metallurgical research for Bell Telephone Laboratories, Murray Hill, N. J., will be the seventh to receive this recognition for outstanding contributions to the development of corrosion technology. The Speller Award, named after F. N. Speller, is in recognition for achievement in the field of corrosion engineering. The Whitney Award, named after Willis Rodney Whitney, is in recognition for achievement in the field of corrosion science. Both awards were made first in 1947 to the persons after whom they are named.

The designees will receive the certificates of award at the annual banquet of the National Association of Corrosion Engineers to be held at Hotel Sherman, Chicago, on the night of March 19. The banquet is a feature of the annual conference and exhibition of the association.

N. E. Berry, immediate past president of the association was chairman of the awards committee. Members were Paul W. Bachman, R. H. Brown, D. B. Good, V. N. Jenkins, J. Flynn Johnston, James T. MacKenzie, M. A. Scheil, L. R. Sheppard, R. S. Treseder, S. E. Trouard, H. H. Uhlig, E. W. Verecke and F. L. Whitney.

Ewing Has Studied Underground Corrosion More Than 30 Years

Extensive experience in solving underground and marine corrosion problems in the background of Scott P. Ewing qualify him as an authority on corrosion. Mr. Ewing, who will receive the Frank Newman Speller Award at Chicago during the NACE Ninth Annual Conference and Exhibition March 16-20 has worked at the research laboratory of The Carter Oil Company at Tulsa, since 1946.

His work at the Carter Oil Company laboratory has been concerned with corrosion of the oil production and transportation equipment of the Standard Oil Company of New Jersey and its affiliates. Among these was an investigation of casing corrosion which has resulted in wider recognition of casing corrosion as a serious problem, and in application of protective measures in several pools. He is engaged now in work on cathodic current requirements for oil field production and pipe line equipment, particularly the determination of current requirements for protection of tank bottoms.

Born in Smithfield, Utah, in 1898, Mr. Ewing was granted a BS degree at Utah State Agricultural College in 1920, and a Ph.D. degree in physics at University of California in 1925.

After a year as physics instructor at Lehigh University and a year in the Soil Corrosion Section of the National Bureau of Standards, from 1928 to 1940 he was Research Associate for the American Gas Association and was stationed at the National Bureau of Standards. His principal interest during this time was pipe coatings and soil corrosion and his book entitled "Soil Corrosion and Pipe Line Protection" was published by the American Gas Association in 1938.

For two years prior to the beginning

of World War II he was employed at the Panama Canal to investigate corrosion problems of steel structures on the canal. As a result of this work, which Dr. F. N. Speller instigated and on which he served as consultant, all the lock gates and some of the other canal structures are now cathodically protected. During World War II he was employed by the Bureau of Ships of the Navy Department and worked on various naval corrosion problems.

Burns Is Author of Many Articles on Corrosion Mitigation

Robert M. Burns, designated to receive the 1953 Willis Rodney Whitney Award of the National Association of Corrosion Engineers for achievement in corrosion science, has been honored frequently by election to offices and other posts of responsibility in the professional and technical organizations to which he belongs. Mr. Burns, chemical coordinator and director of chemical and metallurgical research for Bell Telephone Laboratories at Murray Hill, N. J., joined the laboratories upon their organization in 1925.

Currently chairman of the publication committee of The Electrochemical Society and editor of that society's journal, he has been treasurer, secretary and president of the society. Last January he was awarded the 1952 Perkin Medal, considered to be the highest award for achievement in American industrial chemistry.

He has published numerous articles in the corrosion field and is senior author of the book "Protective Coatings for Metals." He has been engaged for many years in administrative work.

A graduate of the University of Colorado, and later recipient of the honorary

Russian Translations

Richard B. Mudge, North Troy, Vermont, a translator from Russian into English charges \$1 per 100 words for one finished original and two copies. Mr. Mudge specializes in scientific journals and will supply a list of those from which he is prepared to translate on request.

degree of Doctor of Science from that institution, his graduate work at Princeton led to a Ph.D. in 1921. He was elected to membership in the Colorado University chapters of Phi Beta Kappa, Sigma Xi and Tau Beta Pi. His social fraternity is Delta Tau Delta and he has been national president of Alpha Chi Sigma, the professional chemical fraternity. He has long been a member of the American Chemical Society and has been chairman of its New York Section.

In World War I he served in the Chemical Warfare Service, and, after a year of research with Barrett Company, became a member of the technical staff of Western Electric Company before joining Bell Laboratories.

His advocations include book collecting, gardening, walking, skiing and mountain climbing. He has been president of the New York Section of the Green Mountain Club and chairman of the New York Chapter of the Appalachian Mountain Club. He lives with his wife and daughter at Summit, N. J.

ON JO
trolling
gas and

Trante
bonds ti
is needed
specially
found th
tions . .
transmis

Trante
near in t
informat
Johns-M

JOHN
PROD



On varied field applications like these . . .

Johns-Manville

TRANTEX *polyvinyl* **TAPE**

**gives lasting protection
against pipeline corrosion!**

ON JOB AFTER JOB, Johns-Manville Trantex Tape is controlling corrosion and extending the service life of underground gas and oil pipelines.

Trantex is a durable plastic tape that sticks on contact—bonds tightly to the pipeline. No heat or heavy duty equipment is needed in its application. It is easily applied by hand or by specially developed hand-operated machines. Many users have found that field-applied Trantex Tape speeds coating applications . . . lowers construction costs on both large diameter transmission lines and gas distribution systems.

Trantex Tape is a development of Johns-Manville—a pioneer in the manufacture of Asbestos Pipeline Felts. For further information about Trantex Tape, write for copy of PP-26A, Johns-Manville, Box 60, New York 16, N. Y.



	*V-10	**V-20
Dielectric Strength per mil thickness, Approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
Temperature Limit	200 F	200 F
Adhesion oz. per inch width	30	20
Tensile Strength lbs. per inch	30	56
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—

*V-10 is a 10 mil tape for average conditions, and

**V-20 is a 20 mil thickness for use where a more rugged coating is specified, such as to repair enamel coatings.



Johns-Manville TRANTEX *polyvinyl* **TAPE**

PROTECTS PIPELINES AGAINST CORROSION



Gun wrapped in VPI bag is ready to fire as soon as it has been unwrapped.

A remarkable new compound called VPI* now has rust on the run. VPI protects ferrous metals against corrosion during transit or storage, by its vapors.

VPI-coated wrapping paper is the most widely used method of putting the vapor to work. Metals are simply wrapped in the VPI paper and the vapors given off inhibit rust. Proper wrapping and storage will give protection up to 15 years.

VPI, made with Monsanto Dicyclohexylamine, is also available in crystal form. The crystals may be blown on metal surfaces or into machinery. After packaging to seal in the vapors, you can be assured of effective protection against rust. With VPI there is no greasing or degreasing—no skilled labor required.



VPI gives all-weather protection, even in 100% humidity. For information on this new method of fighting corrosion, write MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 800 North Twelfth Blvd., St. Louis 1, Missouri.

*Reg. U. S. Pat. Off. by Shell Development Company



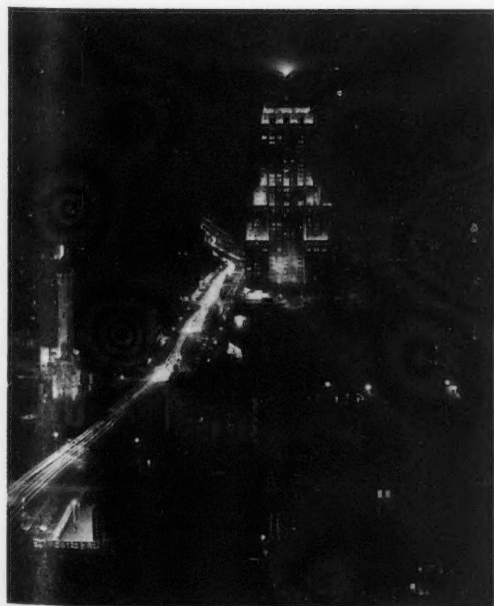
VPI PROTECTS: Aircraft engines, Precision tools, Auto body stampings, Military weapons, Tractors & Heavy equipment, Steel specimens, Finished metal stock, Steel drums, Gears & bearings, Wire & Steel strap, Lathes & Thread grinders, Cigarette lighters, Tank truck interiors, Automotive water pumps, Diesel engines and other metal equipment.

Ninth Annual Conference and Exhibition Section

This view of Michigan Avenue looking north shows the skyscraper office buildings and hotels bordering this street and overlooking Lake Michigan.



Bustling Chicago Offers Abundant Variety To Interest Participants in Conference



THE city that grew from a hamlet to the nation's second largest city in sixty years is often surprising and always colossal. While Chicago is most often thought of as a railroad and manufacturing center, it has developed a great many cultural assets, largely as a result of the beneficence of wealthy citizens.

It is known also as a shopping center and as a focus of the meat packing industry as well as a producer of large volumes of such unrelated products as candy and radar equipment. Located on the shores of Lake Michigan, it uses the lake as a playground and has developed the Chicago River into an inland harbor for commerce. Barge traffic uses the Chicago River and its connected canal system to reach the Mississippi River.

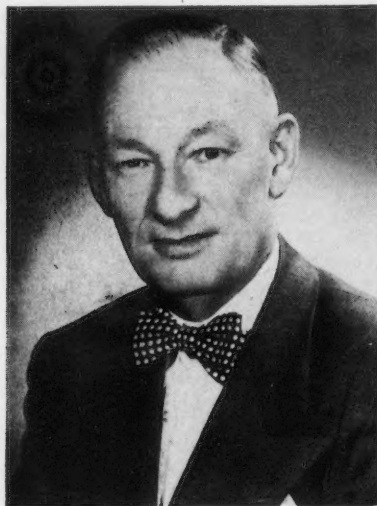
The visitor will find many good hotels and eating places, museums of art and antiquarian interest and the famous museum of Science and Industry, where exhibits are visitor operated.

(Continued on Page 16)



H. L. O'BRIEN

General Chairman, 1953 NACE Conference and Exhibition at Chicago. Mr. O'Brien is product manager of Graver Tank and Manufacturing Co., East Chicago, Ind.



CARL B. SMITH

Dearborn Chemical Company, Chicago, is exhibits chairman for the 1953 NACE Conference and Exhibition.



H. W. SCHMIDT

Technical Program Chairman, 1953 NACE Conference and Exhibition, Chicago. Mr. Schmidt is with the Materials Engineering Service of The Dow Chemical Company at Midland, Mich.

Technical Program Includes 41 Papers, Four Discussion Sessions, Other Events

The technical program for the 1953 Chicago Conference to be held March 16-20 at Hotel Sherman includes 41 papers in nine symposia. Four discussion sessions are scheduled and several innovations have been incorporated in the program.

Meetings of the association's technical committees will be held Monday and throughout the week on a schedule which probably will not be available before the Sunday preceding the opening of the conference. It is necessary to hold the meeting program open until the last minute to accommodate committees and to reduce conflicts.

Among the innovations are three educational lectures to be given March 17, 18 and 19 beginning at 4:30 pm. Three discussion sessions have been programmed for pipe liners also. A pipe line coatings symposium will be held beginning at 9 am March 17 with ten authorities in various areas of the pipe line coating field participating. A number of discussions on pipe line problems, with groups limited to about 30, will be held beginning at 9 am March 18 and a Pipe Line and Underground Corrosion Round Table will be held beginning at 2 pm March 19.

The Chemical Industry Symposium will be held in two sessions to accommodate the large number of papers on widely diversified problems being presented.

A new feature for this conference also will be a round table discussion session on Refinery Corrosion to be held March 17 as a part of the Refinery Industry Symposium.

Requests for questions to be answered at the General Corrosion Problems Round Table and at the Refinery Corrosion Problems Round Tables have been sent out to NACE members. Questions will be accepted from the floor,

and audience participation in supplying answers to all questions is solicited.

Diversified Exhibition Planned for Chicago

Exhibits at the March 16-20 NACE Conference and Exhibition at Sherman Hotel Chicago will exemplify by their diversity the expanding diversification of the interests of NACE members. The pronounced trend in recent years to higher temperatures, pressures and velocities and more highly corrosive environments has attracted exhibits of the latest materials and methods designed to cope with these problems. Latest advances in high temperature metallurgy, significant new discoveries in plastic materials, chemicals and coatings all will be found.

Exhibitors staff their displays with qualified technical people who are available for consultation on corrosion questions and who can give full information on their products. Many working models and full size specimens of equipment are available.

A partial list of the exhibitors follows:

Aluminum Company of America
Amercoat Corporation
American Agile Corporation
Ampco Metal, Inc., Milwaukee, Wis.
Anderson-Prichard Oil Corporation
Apex Smelting Company
Armour and Company
The Barrett Division, Allied Chemical & Dye Corporation
Bart Manufacturing Corporation
A. E. Betzel Engineering Company
Brance-Kracy Company, Inc.
Stewart R. Browne Manufacturing Company, Inc.
Calgon, Inc.
Cameron Iron Works, Inc.

Philip Carey Manufacturing Company,
The
Cathodic Equipment Company
Cathodic Protection Service
Chemical Corporation, The
Cooper Alloy Foundry Company, The
M. J. Crose Manufacturing Company
Dampney Company, The
Dearborn Chemical Company
Dow Chemical Company, The
Dresser Manufacturing Division, Dresser Industries, Inc.
Duriron Company, Inc., The
Electro Rust-Proofing Corp. (N. J.)
Federated Metals Division, American Smelting & Refining Company
Good-All Manufacturing Company
Gray Company, Inc., The
Grinnell Company, Inc.
Harco Corporation
Havco Corporation
Heil Process Equipment Corp., Cleveland, Ohio
Hill Hubbell & Company, Div., General Paint Corporation
Hills-McCanna Company
Insul-Mastic Corporation of America
International Nickel Company, Inc., The
Johns-Manville Sales Corporation
Polyken Industrial Tape, Department of Bauer & Black
Koppers Company, Inc.
Ladish Company
Lebanon Steel Foundry
Lincoln Engineering Company
Lithcote Corporation
Lukens Steel Company
Magnaflux Corp., Chicago, Ill.
MainTcorr, Inc.
Metallizing Engineering Company, Inc.
Metalweld, Inc., Philadelphia, Pa.
Middle West Coating & Supply
Midwest Pipeline Service Company
Midwestern Engine & Equipment Company, Inc.
Minnesota Mining & Manufacturing Company
National Carbon Company
National Lead Company
Nelson Electric Manufacturing Company
Nicolet Industries, Inc.
Nukem Products Corporation

(Continued on Page 16)

These are the FACTS

complete details
available on request

If you are now using COOPER ALLOY stainless steel valves you know all about the plus factors in quality and design that are yours at no extra cost. If you are using any other brand, you owe it to yourself to get the facts and make the comparison. For the full story on how competitive 2" gate valves designed for the same service differ in important service features, write for your free copy of the 2" valve Comparison Chart.

STAINLESS STEEL VALVE COMPARISON CHART

BASED ON 2" GATE	COOPER ALLOY	COMPETITORS		
		A	B	C
Ball and socket rotating type disc for positive seating with minimum galling	✓	✓		
Discs and seats designed for simple reconditioning in the field	✓	✓		
Centerless ground stock to cut packing wear	✓	✓		
3/4" minimum stem diameter to assure rigidity	✓		✓	✓
Deep stuffing box with six turns of 1/4" square packing	✓		✓	
Packing gland designed to deliver square, uniform compression	✓			
Two piece gland construction to prevent gouging of the stem	✓	✓		✓
Swinging eyebolts to simplify repacking and provide added safety	✓			
Simplified yoke nut construction to permit replacement without interrupting service	✓			✓
Grease fitting to eliminate friction on yoke nut during opening and closing	✓			
100% x-ray of vital cast components	✓			
A stainless steel valve designed and produced by stainless steel specialists	✓	✓		
Stocked in major industrial areas by nationwide distributor organization	✓		✓	✓
Rugged construction for tough corrosive service—compare these weights!	33-lbs.	28-lbs.	28-lbs.	24-lbs.
7" minimum diameter handwheel for simplified hand closing	✓			



CUT OUT AND MAIL COUPON BELOW

THE
COOPER ALLOY
FOUNDRY CO. • HILLSIDE, NEW JERSEY

Please send along
my copy of your
detailed chart com-
paring competitive 2"
stainless steel gate
valves

Name _____
Position _____
Company _____
Address _____
City _____ Zone _____ State _____

Bustling Chicago—

(Continued From Page 13)

Usually there is available a choice among shows in legitimate theaters. Numerous well-known and colorful night clubs are available. Shopping in Marshall Field's world-famous store, or in many of the others on State Street and elsewhere in the retail shopping district attract many women visitors.

Tourists have the option of sight-seeing trips by bus or water taxi.

The first permanent European settlement from which Chicago is believed to have sprung was the establishment of Fort Dearborn, built in 1803-4 at the entrance of the Chicago river into Lake Michigan. The spot where the fort once

stood—now overlaid with the steel and concrete of Wacker Drive—is marked by a bronze plaque. In 1812, troops and citizens who had established themselves in the vicinity of the fort were ambushed at the present 18th street and Calumet Avenue by hostile Indians under Tecumseh while fleeing from the area.

In 1833, after the Black Hawk war, when the Indians were persuaded to move west of the Mississippi, the settlement of 550 residents was incorporated as a town. Four years later there were over 4000 people and the town received a city charter. The real growth of the city did not begin until the coming of the railroads, the first of which, the Galena and Chicago Union, was begun in 1847. The city almost trebled in population during the Civil War.

In the great fire of 1871 damage was about \$200,000,000 and 17,000 buildings were destroyed and 100,000 people made homeless.

It has been the scene of two major expositions and numerous smaller ones.

Diversified Exhibition—

(Continued From Page 14)

Perrault Equipment Company
Pipe Line Anode Corporation
Pipe Protection Service, Inc.
Pittsburgh Coke & Chemical Company
Prufcoat Laboratories, Inc.
Reilly Tar & Chemical Corporation
Ric-Wil Plastic Coating & Manufacturing Corporation
Royston Laboratories, Inc.
Rust-Oleum Corporation
Saran Lined Pipe Co., Ferndale, Mich.
Service Engineers, Inc.
Shell Oil Company
Socony Paint Products Company
Standard Magnesium Corporation
Standard Pipe Protection
D. E. Stearns Company, The
Tapecoat Company, The
Tennessee Eastman Company
Tretolite Company
Triangle Conduit & Cable Co., Inc.
Plastic Products Division
United Chromium, Inc.
U. S. Stoneware Company, The
Wolverine Tube Division, Calumet and
Hecla Consolidated Copper Company
T. D. Williamson, Inc.



PAINT STEEL

CLEAN OR RUSTED

WET OR DRY

WITH

TYGORUST

TYGORUST is the new "no-prep" vinyl primer that adheres tenaciously to steel and iron—clean or rusted—wet or dry. It applies easily by brushing or spraying. It covers up to 600 square feet per gallon. It dries hard in minutes. It can be top-coated in an hour, or less. It provides excellent adhesion for all types of finishes. It inhibits rust formation. It has good chemical resistance.

TYGORUST can also be used to prime concrete, wood, and previously painted surfaces (asphaltic coatings excepted). It is particularly recommended as a primer for chemically resistant, vinyl-based coatings.

For minimum surface preparation, use TYGORUST! For maximum chemical resistance, use TYGORUST top-coated with TYGON "Series TP" Paint!

WRITE TODAY
FOR FULL
DETAILS!

390C

THE U. S. STONWARE CO.
Plastics and Synthetics Division
AKRON 9, OHIO



AICHe Award Given To Harold F. Hublein

Harold F. Hublein, chemical engineering graduate of Cooper Union for the Advancement of Science and Art has won the A. McLaren White award for his solution of an engineering contest problem sponsored by the American Institute of Chemical Engineers. The problem concerned the peace-time use of atomic energy and required the engineering design of an atomic power system for the conversion of kinetic energy released by the nuclear fission into useful electrical or mechanical power. Second prize went to Rodney A. Nelson, a graduate of the University of Minnesota, and third prize to David G. Stephan, a recent graduate of Ohio State University.

Thomas Baron, Shell Development Company, Emeryville, Calif., and Lloyd G. Alexander, Oak Ridge National Laboratory, Oak Ridge, Tenn., were chosen by the Society to receive the 1952 Junior Award in chemical engineering. The honor is given annually for outstanding contributions to the literature or chemical engineering.

The two young chemical engineers collaborated in a study entitled, "Momentum, Mass and Heat Transfer in Free Jets."

Electrochemical Society To Meet April 12-16

The latest information on new techniques involving electro chemical principles as now applied by medical and biological scientists will be presented in a "Symposium on the Application of Electrochemistry to Biology and Medicine" at the Spring meeting of the Electrochemical Society to be held at the Statler Hotel, New York City, April 12 to 16.



CATHODIC PROTECTION SERVICE

FEATURES

A COMPLETE LINE of

CATHODIC PROTECTION SUPPLIES

DOW MAGNESIUM ANODES

Available in types to meet the needs of corrosion protection for all buried or under-water metal structures, including pipe lines, gathering lines, tank bottoms, etc.

GOOD-ALL RECTIFIERS

Available to your specifications in both oil-immersed and air-cooled models, Good-All Rectifiers are among the most efficient in service today. They are ruggedly built to withstand the ravages of wind, rain, sleet and a wide range of temperature changes.

CPS GRAPHITE ANODES

Available for immediate delivery. Equipped with SUPER STRONG LEADS that will not pull out, even under excessive weight loads. Normally supplied with 3 ft. of No. 6 direct burial cable, but we will attach leads to your specifications.

POLYKEN PROTECTIVE TAPE COATINGS

Featuring the new 8 mil film (rather than 7 mils) with greater tear resistance, greater tensile strength, better puncture resistance, plus all the recognized superior qualities of polyethylene, among which are a very low moisture vapor transmission rate, inertness to chemicals, and high dielectric strength.

Write, wire or phone for full descriptive information.



OTHER FIRST LINE MATERIALS INCLUDE:

Dow Magnesium Anodes
Good-All Rectifiers
Maloney Insulating Materials
Erico Cadweld Welding Materials
Fisher M-Scope Pipe and Cable Locators
Homco and Barada and Page Backfills
CPS Graphite Anode Backfills
Agra and Collins Meters
Associated Research Resistivity Meters
Rubicon Potentiometers
Pearson Holiday Detectors
Holloway Shunts
Polyken Protective Tape Coatings

DISTRIBUTED BY

cathodic protection service

OFFICES LOCATED IN

HOUSTON
4601 Stanford St.
Houston 6, Texas
Phone JA-5171

TULSA
314 Thompson Bldg.
Tulsa, Oklahoma
Phone 2-9857

NEW ORLEANS
1639 Robert St.
New Orleans 15, La.
Phone CH-8310

Everything in the cathodic protection field . . .
from an insulating washer to a turnkey contract installation

4 Papers to Be Given on Electrode Potentials

In recognition of the urgent need for a better understanding of the fundamentals of corrosion processes, the technical program at Chicago will include four papers on fundamentals, all by recognized authorities. It was the custom at previous NACE Conferences to have one paper only on fundamentals and while this served a useful purpose, the expansion of the fundamentals presentation into a full symposium was considered worthwhile and sure to be of interest to registrants.

The symposium will be held from 9 to 11 a.m. on Tuesday, March 17, the opening event of the technical program. It is somewhat shorter than other morning symposia because of the necessity of holding the annual business meeting of NACE on Tuesday morning.

Titles and abstracts of the four papers to be presented are given on this page.

Fundamental Concepts of Electrode Potentials

By Andre J. de Bethune, Chemistry Department, Boston College, Chestnut Hill, Mass.

Abstract

The potential differences observed at metal liquid interfaces arise as a result of two distinct phenomena: 1) at reversible electrodes, phenomena associated with Faraday's Law; 2) at polarized electrodes, phenomena associated with the charging of the double layer. At reversible (or nearly reversible) electrodes, electricity can flow through the interface by the mechanism of an electron exchange reaction between the metal and the chemicals present at the electrode surface. When electrons are donated by the metal (reduction), the electrode is a cathode (— terminal in an electrolytic cell, + terminal in a galvanic cell such as a local cell on a corroding metal). When electrons are removed by the metal (oxidation), the electrode is an anode (+ terminal in an electrolytic cell, — terminal in a galvanic cell). When electron exchange is at equilibrium, the electrode potential is governed by the Nernst equation and is determined primarily by the difference in free energy of the oxidized and reduced forms of the electrode chemicals (standard potential) and secondarily by the concentrations (thermodynamic activities) of these chemicals (mass action effect). The standard hydrogen electrode (S. H. E.) provides a convenient reference point from which to measure potential differences. With a net current flowing, the electron exchange is not at equilibrium and the potential of the electrode may be displaced from the reversible value (polarization potential or overvoltage). Polarization as an anode shifts the potential in a noble direction; as a cathode, in a non-noble direction. With nearly reversible electrodes, small concentration polarizations (eg. 0.1 volt) may occur.

At an "ideally" polarized electrode, electricity cannot flow through the interface which then acts as an electrical condenser (electrical double layer). The potential of the electrode is determined by the charge and capacitance of the

double layer. This capacitance is not necessarily a constant but is generally of the order of magnitude of 20 microfarads per cm². The potential of zero charge (the "electrocapillary maximum") is now known, on mercury in the presence of indifferent electrolytes, to be 0.20 volts more negative (less noble) than the S. H. E. No real electrode is ever "ideally" polarized. Electrode reactions may set in with sufficiently high polarizations (eg. 1 volt). In this case, however, the electrode potential is not determined primarily by the electrode reaction but by the degree of charging of the double layer. The current flowing must be visualized as a "leakage" current between the double layer "plates." This current must overcome a high chemical activation barrier in the path of the electrode reaction. The current-voltage curve at an electrode is known as a polarization curve and throws important light on the behavior and reactivity of the electrode surface.



de Bethune

The Measurement of Electrode Potentials

By Norman Hackerman, University of Texas, Department of Chemistry, Austin.

Abstract

The measurement of the potential of a metal under given conditions is in reality the measurement of a difference in potential between the metal and a reference electrode or half cell. There are a number of reference electrodes available for use under varied circumstances, but those of most interest to the corrosion worker are the calomel half cells and the copper-saturated copper sulfate half cell. The principle, preparation and use of these are described in some detail.



Hackerman

potential against that of a cell of known potential. The sensitivity needed governs the specific instrument to be used. The accuracy obtainable depends on the ease



Petrocelli



Godard

J. V. Petrocelli, director of research of the Patent Button Company, Waterbury, Conn., left, and H. P. Godard, right, Aluminium Laboratories, Ltd., Kingston, Ont., are co-chairmen of the Corrosion Principles Symposium. Both are interested in the fundamentals of corrosion processes. Mr. Godard is 1952-53 chairman of the Inter Society Corrosion Committee and is a member of the NACE board of directors.

with which the cell is polarized since a finite current is needed to actuate the indicator mechanism of any type of potential measuring instrument. In addition, for cells of high resistance even very small currents introduce appreciable IR corrections. Correction for potential differences across liquid-liquid interfaces need be made only if values to ± 1 mv are needed. Normally, potential measurements of interest in corrosion problems need be known to no better than ± 5 mv and oftentimes even greater variability is not harmful. Voltmeters and potentiometers for the normal range of problems are described.

The Interpretation and Significance of Potentials of Metals in Aqueous Solutions

By Morris Cohen, Corrosion Section, National Research Council of Canada, Ottawa, Canada.

Abstract

The potential of a metal in an aqueous solution is dependent not only on the reaction or reactions which are taking place between the metal surface and the environment, but also depends on the physical nature of the system. When a metal is corroding not only is the system not in equilibrium but there is usually more than one reaction taking place. The potential which is measured is therefore a mixed polarized potential.



Cohen

Because of this, the measured potential is a poor criterion of the corrosion resistance and must be considered in relation to the environment. Examples of the potentials of iron in various systems are given and the main factors determining these potentials are outlined.

(Continued on Page 20)

APPLYING "Scotchrap" Pipe Insulation is a quick, easy job—requires no special equipment.



"Scotchrap" cuts coating costs in half!

Remarkable savings reported on installation of gas line at Glen Lake, Minn.

Six hundred feet of buried gas line protected against corrosion for less than half the usual costs! That's the story from John L. Hanson, Secretary of Bjorkman Brothers Co., Minneapolis, contractors for the job at Glen Lake Sanatorium. And "Scotchrap" Pipe Insulation made those savings possible.

"Scotchrap" is a tough plastic tape with a pressure-sensitive adhesive that sticks to the job right off the roll.

That means no special applying equipment is necessary—although "Scotchrap" can be machine wound if you prefer. It means faster

"on the spot" coating without the danger of scalds and burns from usual methods.

And "Scotchrap" lasts and lasts. Plastic backing resists acids, alkalies, alcohols, water, oils, fungus, bacteria—even galvanic and electrolytic action.

Try it *yourself* and see. Order a supply today!



John L. Hanson, Secretary
Bjorkman Brothers Co.,
Minneapolis, Minn.



REG. U.S. PAT. OFF.
SCOTCHRAP
BRAND
PIPE INSULATION

The term "Scotch" and the plaid design are registered trademarks for the more than 200 pressure-sensitive adhesive tapes made in U.S.A. by Minnesota Mining & Mfg. Co., St. Paul 6, Minn.—also makers of "Scotch" Sound Recording Tape, "Underseal" Rubberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-slip Surfacing, "3M" Abrasives, "3M" Adhesives. General Export: 122 E. 42nd St., New York 17, N. Y.
In Canada: London, Ont., Can.



4 Papers to Be—

(Continued From Page 18)

Electrode Potentials of Corroding Metals

By Thomas P. May, and F. L. LaQue,
The International Nickel Company,
67 Wall Street, New York 5, New
York.



LaQue



May

Abstract

Following a brief review of reversible electrode potentials, irreversible electrode potentials of corroding metals are discussed with particular reference to corrosion rates. Experiments in sea water provide further evidence that neither reversible or irreversible potentials can be used to estimate corrosion rates. The concept of local cell action as used by Mears and Brown is used to explain this lack of coordination. This concept is then applied to galvanic couples of dissimilar metals and alloys to account for the observed galvanic corrosion. Polarization curves of local

anodes and cathodes on carbon steel are estimated by using corrosion rates and potential measurements on anodically and cathodically polarized specimens in sea water.

Continuous Casting of Steel to Begin Soon

First commercial installation of a new type machine that converts molten steel into solidified billets or slabs in a continuous line will be started at Welland, Ontario, Canada within a few months, according to The Koppers Company, Inc., which designed and will construct the continuous casting plant for Atlas Steels Ltd., of Welland.

This revolutionary development will, according to the Koppers Company, yield from 10 to 15 percent more finished steel per heat than conventional pouring methods. The new method will allow by-passing of the blooming mill and soaking pits in the steel-making operation. Although the machine can be adapted to cast all ferrous-metal types, including mild steels, greatest savings to steel companies will accrue in continuous casting of specialty steels, according to Koppers Company spokesmen.

In each December issue of Corrosion there is published a tabular cross-indexed reference to all technical material published in the preceding 12 months. This table includes a chronological list of papers and authors, by page numbers and an alphabetical list of authors.

Ewing Heads Local Arrangements Group

L. W. Ewing, assistant chief engineer of Standard Oil Company (Indiana) Products Pipe Line Department, is Local Arrangements Chairman for the Chicago 1953 Conference and Exhibition. Mr. Ewing is responsible for arranging the program of ladies' entertainment, entertainment for the annual banquet and other events at the conference.



Ewing

A graduate of the University of New Hampshire, his experience includes work with U. S. Engineers on flood control and airport construction, pipe line and storage facilities for the Navy Department in Panama and installation of a cathodic protective system on the lines.

Committee Meetings

A schedule of technical and standing committee meetings will be printed separately from the official program, with a chronological table of meetings and a copy of the meeting room floor plan. Copies of this schedule will be available at the registration desk and at the NACE booth.

ACIPCO Pipe for Permanence!

ACIPCO pipe has the lasting strength that enables it to survive continued corrosive attack, year after year, and to keep on giving the same dependable, economical service as the day it was installed. It is manufactured by the Mono-Cast centrifugal process in diameters 3-inch through 48-inch.

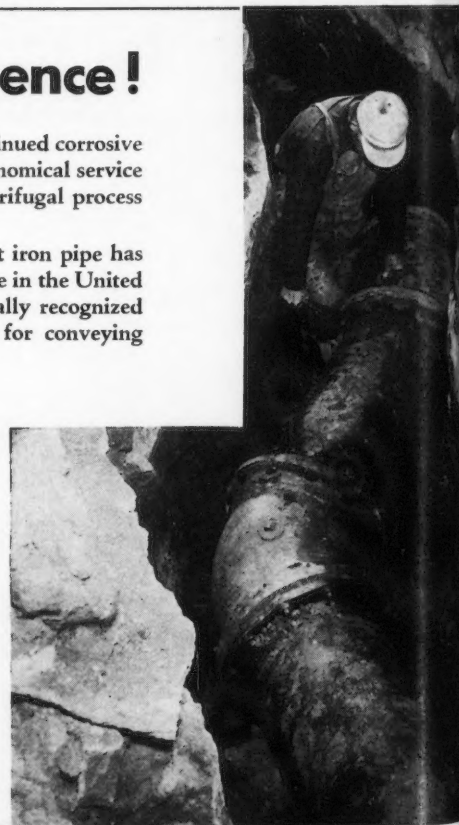
Being cast iron, ACIPCO pipe enjoys an enviable reputation. Cast iron pipe has had over 300 years of service abroad and more than 100 years of service in the United States. ACIPCO pipe is produced under close control to meet nationally recognized standard specifications. It can be supplied with a variety of joints for conveying chemicals, salt brine, gasoline, gas, sewage, oil, water and other liquids under every service condition. Among the joints available are American Double-X, Flanged, Screw-Gland, Molox Ball Joint, Roll-On and Bell and Spigot.

For many years our Company has pioneered in research, maintaining an experienced staff of chemists, metallurgists, engineers, and fully equipped modern laboratories. Refer your next piping problem to ACIPCO and utilize our extensive manufacturing facilities.

Write for free literature, stating the kind of joint in which you are interested.

**AMERICAN
CAST IRON PIPE
COMPANY**

Birmingham 2, Alabama



MEMO: Make the B-K booth your convention "headquarters"



OUR BOOTH at the N.A.C.E. National Convention last year at Galveston, Texas.

Yes, this year at the N.A.C.E. National Convention make it a point to drop by the BRANCE-KRACHY booth to visit with us and your friends. We will be located next to the Federated Metals booth in numbers 57 and 58. As in past years, we will feature our complete line of cathodic protection equipment with full details of interest to you.



N.A.C.E. NATIONAL CONVENTION

Hotel Sherman • Chicago
MARCH 16-20

Brance-Krachy Co. INC.

4411 NAVIGATION • P.O. Box 1724 • HOUSTON

4411 NAVIGATION BLVD., P. O. BOX 1724, HOUSTON
2850 E. FLORENCE ST., HUNTINGTON PARK, CALIFORNIA
P. O. BOX 66, BEAUMONT, TEXAS

Authorities on Pipe Line Coatings Will Speak

Ten authorities on pipe coating and wrapping representing as many segments of the pipe coating industry will lead discussions during the Pipe Line Coatings Symposium which will be held at Chicago from 9 to 11 a.m., Tuesday, March 17. Each of the experts will



Lopez

make a brief presentation, after which discussion will be opened. This is one of four items on the technical program of special significance to pipe liners and those concerned with underground corrosion. E. R. Lopez of The Barrett Division, Allied Chemical & Dye Corp., New York is symposium chairman.

The names of those who will speak, not necessarily in the order of their speaking are as follows:

Ray L. Smith, Ray L. Smith & Son Company, El Dorado, Kansas, representing general construction contractors.

R. E. Shackleford, Perrault Equipment Company, Tulsa, Okla., representing coating equipment manufacturers.

Hugh L. Hamilton, The A. V. Smith Co., Bala Cynwyd, Pa., representing consulting engineers.

A. D. Simpson, Jr., United Gas Corp.,



Smith



Shackleford



Hamilton



Bowen



Fair



Broyles



Schultz



Liggett

Houston, representing pipe line owners.

M. M. Bowen, Hill Hubbell Division, General Paint Corp., Cleveland, Ohio,

representing factory coating applications. W. F. Fair, Jr., Koppers Co., Inc., Westfield, N. J., representing coal tar coating manufacturers.

Wayne E. Broyles, Brance-Kratch Co., Inc., representing asphalt coating manufacturers.

Wayne H. Schultz, Dearborn Chemical Company, Chicago, representing petroleum base coating manufacturers.

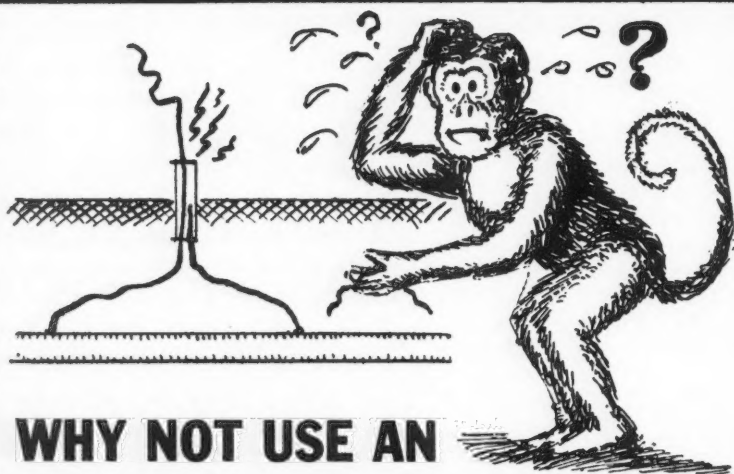
E. J. Liggett, Johns-Manville Sales Corp., Tulsa, representing asbestos fabric manufacturers.

R. W. Farriss, Owens-Corning Fiberglass Co., Newark, Ohio, representing glass wrapper manufacturers.

Professional Engineers Seek Manpower Aids

The National Society of Professional Engineers has published a research report entitled, "How To Improve the Utilization of Engineering Manpower." Purpose of the report is to give the "how to" of easing the demand for more engineers through better engineering staff utilization. The scope of the survey on utilization was nationwide. It was conducted by means of questionnaires, personal inquiry, research and consultation.

The report points out that while much of the growing demand for engineers is a result of the defense program, the greatest demands arise from the increase of engineering man-hours required to maintain our mode of living. The report is one of a series of four reports to be made by the association. These are: 1) How to Improve Engineering Management Communications, (already published); 2) How to Improve the Utilization of Engineering Manpower (just recently published); 3) How to Attract Qualified Engineers; and 4) How to Train Engineers in Industry.



WHY NOT USE AN ELECTROLYSIS CHECK POINT?

- ★ No broken wires
- ★ Positive line identification
- ★ Positive electrical contacts
- ★ Versatile connections for bending
- ★ No probing through pipe coating

SERVICE ENGINEERS, INC.

Manufacturers of Industrial Plastic Products

3030 W. Pafford

P. O. Box 11068

Fort Worth 9, Texas



... for you to visit us at our booth at the 1953 NACE Convention in Chicago

In the past year more pipeline companies have depended on T. D. Williamson, Inc., than ever before . . . for WmSeal Casing Bushings and Concentric Support Insulators for use where pipelines pass through right-of-way crossings . . . for Williamson Pipeline pigs, that keep pipelines clean and trouble-free . . . for Hillico Tapping Machines that make lateral connection to pipelines under pressure . . . and for other specialized pipeline equipment. We sincerely appreciate the confidence that the pipeline industry has placed in us and our products. We shall look forward to meeting with all the delegates at the convention . . . Be sure to visit us at our booth.

T.D. Williamson, Inc.



**THE PIG WITH THE POKE
CLEANS PIPE LINES**

P. O. BOX 4038
TULSA 9, OKLAHOMA

REPRESENTATIVES

CANADIAN EQUIPMENT
SALES & SERVICE CO., LTD.
EDMONTON, CALGARY,
TORONTO, CANADA

LANGLEY Y CIA.
BUENOS AIRES, ARGENTINA

KERR ENGINEERED SALES CO.
PITTSBURGH 22, PENNSYLVANIA

BEN W. BRUNDAGE COMPANY
OAKLAND 11, CALIFORNIA

STUART STEEL PROTECTION CORP.
KENILWORTH, N. J.

H. E. DAVIS
LOS ANGELES, CALIF.

JAMES S. KONE CO.
AMARILLO, TEXAS

HAMMOND IRON WORKS
KEYES TANK DIVISION
CASPER, WYOMING
PROVO, UTAH

Fresh and Salt Water Symposium Has Five Papers

Five papers on five diverse subjects will be given during the Corrosion by Fresh and Salt Water Symposium at Chicago Tuesday, March 17 from 2 to 4:30 p.m. The papers range from such subjects as the use of chromates in methanol antifreeze to the effects of corrosion and erosion on steel piers on the California coast.

V. V. Kendall, of National Tube Division, U. S. Steel Corp., Pittsburgh and Sheppard T. Powell, consulting engineer of Baltimore are chairmen of the symposium.

Biographies of authors and abstracts of the papers to be given follow.

Chromate for Corrosion Control in Methanol Antifreeze

By George E. Best, Mutual Chemical Company of America, 1348 Block Street, Baltimore 31, Maryland and Eugene A. Roche, American Chemical Paint Company, Ambler, Pennsylvania



Roche



Best

George E. Best, a native of Maine, attended elementary schools in South Portland and Portland and in 1934 was graduated from Massachusetts Institute of Technology in Electrochemical Engineering. The next ten years were spent in process metallurgy research with The New Jersey Zinc Co. at Palmerton, Pa., followed by three years at Wyandotte, Michigan, with Pennsylvania Salt Manufacturing Co. as a production supervisor. Early in 1948 Mr. Best came to Mutual Chemical Company of America in Baltimore, Md. where he has been engaged in technical service and development activities.

Eugene A. Roche joined the Research and Development Department of the Mutual Chemical Company in 1941 where he studied the uses and properties of chromium compounds including the use of chromates as corrosion inhibitors. After service as instructor, Army Air Force 1943-1945, he returned to technical service work at Mutual.

Mr. Roche holds the degrees of bachelor of chemical engineering from Johns Hopkins University and is now serving the Middle Atlantic territory as sales engineer in the Rust-proofing & Metal Working Chemicals Division of the American Chemical Paint Company of Ambler, Pennsylvania.

Abstract

The efficacy of chromate for preventing corrosion under a wide variety of conditions is well known. Where organic media are concerned, however, there arises the question of reactivity because of the oxidizing power of hexavalent chromium and each situation requires individual evaluation.

Use in methanol antifreeze may now be added to the increasing number of effective applications with organic materials. Confirming data are reported from two winter seasons of field trial in operating vehicles and specific suggestions given regarding chromate concentrations, servicing, etc.

The Effect of Operating Conditions on Pipe Corrosion in Buildings

By H. L. Shuldener, Water Service Labs., 423 West 126th Street, New York, New York.

Henry L. Shuldener, president and technical director of Water Service Laboratories, New York is a native of New York City. Educated in the New York Public Schools, and graduated from the New York University School of Engineering in 1920 with a degree of bachelor of science in chemical engineering. His whole professional life has been devoted to the field of water treatment and corrosion prevention. In 1927 he founded the company he now heads, is inventor of several chemical feeding devices and has had many technical articles published. He is a member of Association of Consulting Chemists and Chemical Engineers, ACS, NACE, AICHE, AWWA, Electrochemical Society and other organizations.

The useful life of piping systems in buildings is influenced not only by the character of the water and its potential corrosiveness and scale-forming properties by the kind of piping whether it be iron, steel, brass or copper but by a group of other factors which may be grouped as operating conditions.



Shuldener

Included in operating conditions and having great influence on them is the design and fabrication of building water distribution systems. An understanding of them will make for improved service and longer pipe life.

One of the most important operating conditions in buildings is maintenance of hot water circulation. Failure to do so results in a number of problems, one of which is fluctuating water temperatures. This frequently leads to overheating of the water and consequent accelerated corrosion and leaks at joints due to excessive expansion and contraction strains.

Modern hot water generation and distribution involves the use of control devices such as aquastats and mixing valves, which the ordinary building superintendent is not normally experienced to adjust and maintain, so that many pipe systems are being ruined by excessively high hot water temperatures.

Corrective treatment of the water supply can be very effective in retarding corrosion and thus expanding the useful life of the piping system.



Kendall

Corrosion Testing by Measurement of Local Cell Action Potentials

By James K. Rice, Cyrus Wm. Rice and Company, 17 Noble Avenue, Pittsburgh 5, Pennsylvania

James K. Rice, vice president and director of service of Cyrus Wm. Rice and Company, Pittsburgh, started work with his employer in 1947, first in research and development and later in field engineering. He has a master's degree in chemical engineering from Carnegie Institute of Pittsburgh. He was an engineering officer in the Marine Corps during the war. He is a member of Sigma Chi, Tau Beta Pi, AICHE, and ASTM.

Abstract

The method of studying corrosion rates by measuring the local cell action potential, using a rotating electrode and stationary microprobe reference electrode, is briefly reviewed. The results are presented of applying the method to the study of the effect of different variables on the corrosion inhibition properties of hexametaphosphate on steel in aerated water systems.



Rice

Affects of Corrosion and Erosion on Some Steel Piers Along the Southern California Coast

By E. O. Kartinen, Signal Oil & Gas Company, 811 West Seventh Street, Los Angeles 14, Calif.

Ernest O. Kartinen, with Signal Oil and Gas Company, Los Angeles, joined the company in 1941 as a mechanical engineer in the construction and engineering department. He holds a BS in mechanical engineering from Washington State College, 1935. He is active in the American Petroleum Institute, NACE and the Sea Horse Institute.

Abstract

During 1928 and 1929 oil was discovered along the sea coast in Santa Barbara County in Southern California. The oil producing zones extend offshore beyond the high water mark, which necessitated the construction of seven piers for purposes of drilling. The piers vary in length from 300 feet to 2300 feet and extend seaward from the high water mark on the shore to water depths of up to 35 feet.

Basically the design is similar on all piers; concrete caissons for the well foundations, steel H-piles with wooden caps, stringers and decking on the approaches to these caissons.

During the past twenty-two years many interesting lessons in corrosion and erosion of steel exposed to the sea have been observed. Study seems to indicate the existence of seven separate and distinct areas of corrosion and erosion. An effort is

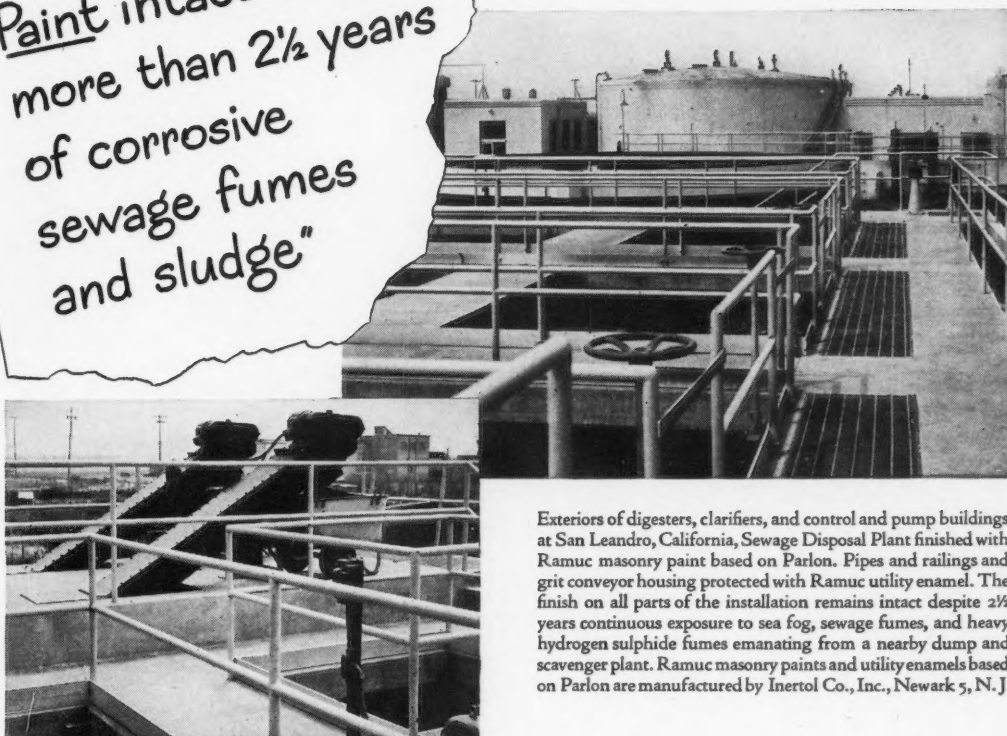


Kartinen

(Continued on Page 26)

Parlon Stays On!

"Paint intact after more than 2½ years of corrosive sewage fumes and sludge"



Exteriors of digesters, clarifiers, and control and pump buildings at San Leandro, California, Sewage Disposal Plant finished with Ramuc masonry paint based on Parlon. Pipes and railings and grit conveyor housing protected with Ramuc utility enamel. The finish on all parts of the installation remains intact despite 2½ years continuous exposure to sea fog, sewage fumes, and heavy hydrogen sulphide fumes emanating from a nearby dump and scavenger plant. Ramuc masonry paints and utility enamels based on Parlon are manufactured by Inertol Co., Inc., Newark 5, N. J.

SEWAGE FUMES and sludge...hydrogen sulphide gases...heavy salt sea fog...heat...cold...condensation...day in and day out! How long can exterior paints take this punishment? At California's San Leandro Sewage Disposal Plant, Inertol's Ramuc paint based on Hercules Parlon (chlorinated rubber) continues to protect and beautify masonry and metal after more than 2½ years of severe exposure.

Wherever corrosion is a problem, not only in sewage disposal plants and water works, but in paper and textile mills, metal refineries, breweries—to name a few of the many places where Parlon-based finishes now serve—you can depend on these sturdy protective coatings to check attacks from acids and alkalis, to give better service at lower long-term costs. See your paint supplier for details on Parlon paints, or write:

Cellulose Products Dept., **HERCULES POWDER COMPANY** 999 King St., Wilmington 99, Del.



Parlon® CHLORINATED RUBBER PAINTS

AVAILABLE FROM 400 PAINT MANUFACTURERS UNDER THEIR OWN BRAND NAMES

Refinery Symposium Features Discussion Session

A paper related to the sulfide corrosion problem now being investigated by technical committees of NACE and another paper on inspecting refinery equipment for corrosion will be given during the Refinery Industry Symposium at the Sherman Hotel, Chicago, during the Ninth Annual NACE Conference and Exhibition. The symposium will be held from 2 to 4:40 p.m. on Tuesday, March 17.

A feature of the symposium will be a discussion session on refinery corrosion problems to be held after presentation of the two papers. This discussion, questions for which have been solicited from NACE membership, will be the first on refinery corrosion problems held at a national meeting of the association. This is expected to be a very interesting feature and to attract wide participation.

Hydrogen Penetration of Steel in Hydrogen Sulfide Solutions

By T. Skei and A. Wachter, Shell Development Company, Emeryville, Cal.



Wachter



Skei

Aaron Wachter, head of the corrosion department of Shell Development Company, Emeryville, Calif., holds a Ph.D. from the University of California, 1930. His principal activities are in corrosion prevention in the operations of the petroleum industry. Dr. Wachter, an early member of NACE, is active in its technical committees, as an author of technical papers and has been elected vice-president of NACE for 1952-53.

T. Skei, chemist in the Corrosion Department of Shell Development Company, received a BS in chemistry in 1939 from California Institute of Technology and a PhD in physical organic chemistry in 1942 from University of California, Los Angeles. He was instructor in chemistry and Research Associate of the Office of Scientific Research and Development at Northwestern University from 1942 to 1944

and joined Shell Development Company in 1944 as chemist in the Process Development Department. As a member of the Corrosion Department, since 1947 he has been engaged in corrosion prevention problems involving various phases of petroleum operations.

Abstract

Extensive damage to some refinery equipment has occurred owing to penetration by the hydrogen formed during corrosion of steel by hydrogen sulfide solutions. Damage in the form of hydrogen blistering, fissuring and embrittlement of steel has been particularly severe in catalytic cracking gas plants. Laboratory investigations have been made of the relative influence of environmental factors on the rate and extent of hydrogen penetration of carbon steel. These studies include determination of the effects of concentration of important constituents such as hydrogen sulfide, low molecular weight organic acids, ammonia and hydrogen cyanide. Several other compounds were studied and found to be of minor importance. The laboratory method involved measurement of the volume of hydrogen which passed through to the opposite side of a thin wall of carbon steel. In certain hydrogen sulfide environments hydrogen penetration practically ceased after a short time interval. Such behavior is ascribed to formation of a protective scale of iron sulfide. However, in certain alkaline solutions containing cyanide ions corrosion and a high continuing rate of hydrogen penetration occurred owing to formation of a ferrocyanide complex which prevented development of a protective scale. On the basis of the data obtained it is shown that rate of hydrogen penetration may be reduced by indicated changes in chemical environment.

Inspection of Petroleum Refinery Equipment

By Edward H. Tandy, Head Equipment Inspector, El Segundo Refinery, Standard Oil Co. of California, El Segundo, California

Edward H. Tandy attended the University of California at Los Angeles and Berkeley, majoring in mechanical engineering. Employed by the Standard Oil Company of California in 1930 he spent eight years in service station and sales work before transferring to the manufacturing department in 1938. Since that time he has been closely associated with materials, corrosion and equipment inspection problems at the Richmond and El Segundo Refineries. He was appointed to the position of Head Equipment Inspector at the El Segundo Refinery in 1948. He has been a member of the Los Angeles Section of NACE since 1948.

Abstract

The conditions created by the presence



Harnsberger



Treseder

of corrosive compounds in crude oils the formation of corrosive compounds during processing and by the use of corrosive process chemicals requires constant inspection of refinery equipment. The refinery equipment inspector must be familiar with the construction and operation of the equipment so that he can anticipate and forestall expensive equipment replacements. Corrosion caused by hydrogen sulfide which is formed during distillation by the breakdown of sulfur compounds can usually be predicted. However, the inspector must always be alert for localized overheating which will accelerate the corrosion rate. Naphthenic acids are most corrosive at their condensation points. Their presence in the crude oil or their formation during refining may cause severe localized corrosion wherever they are condensed or evaporated. Corrosion in gasoline storage tanks which is caused by the presence of moisture, oxygen and slight concentrations of other gases, proceeds at a low rate as compared to corrosion in distillation equipment, nevertheless, it is responsible for major repairs.



Tandy

Fresh and Salt Water—

(Continued From Page 24)

been made in this discussion to enlarge on the subject as outlined below:

1. Spray area shoreward of breakers
2. Breaker area
3. Sand line corrosion—erosion
4. Atmospheric corrosion above normal high-water line
5. Corrosion at high-water line
6. Underwater corrosion between low-water line and mud line
7. Mud line corrosion

These data have been gathered piecemeal over the past ten years. The IPY data were acquired by caliper measurements of piles in place by diver, as well as piles that have been removed. Pictorial representation is by slides as well as by movies. No attempt will be made at this time to do more than present the data. The theory and mechanics of the corrosion and erosion processes will be left for future discussion.

NACE Central Office To Have Exhibit Booth

The booth of the National Association of Corrosion Engineers' Central Office will display copies of association publications for inspection, bound volumes of the association's periodical "Corrosion," samples of the Abstract Card and copies of the guide to the use of the service and other material. A representative of the association will be at the booth to answer questions and take orders for publications and accept applications for membership.

Many members take the opportunity during the conference to visit the NACE booth and inspect the association's printed material.

Ladies' Program

The ladies' program for the Chicago Conference will be organized by Convention Management, with which a contract has been signed by the association.

RESISTS HOT ACETIC ACID and CHLORIDE VAPORS

AT 158 TO 284

DEG. F.



HASTELLOY alloy expansion joint

This HASTELLOY alloy C expansion joint is constantly exposed to acetic acid vapors saturated with acetyl chloride and containing small amounts of chloracetic acid. Alloy C is practically unaffected by these corrosive vapors at temperatures of 158 to 284 deg. F. Used at the top of a 24-foot distillation still, the joint is also elastic enough to compensate for the almost half-inch growth of the heated tower.

HASTELLOY alloy C and the other two grades of this nickel-base alloy—alloys B and D—are excellent construction materials for all types of processing equipment that must resist corrosive attack. In addition to their unusual corrosion resistance, alloys B and C have high mechanical strength and are available in both cast and wrought forms. Alloy D is available in cast form only. All three alloys are readily fabricated by most common methods. Fill out the handy coupon below for the whole story on these alloys.

"Haynes" and "Hastelloy" are trade-marks of Union Carbide and Carbon Corporation.

HAYNES
Trade-Mark

Alloys

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation

UCC

USE THIS
HANDY
COUPON

Haynes Stellite Company, 725 So. Lindsay Street, Kokomo, Indiana
Please send me the new edition of your booklet, "HASTELLOY
High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

NAME _____

COMPANY _____

ADDRESS _____

Elevated Temperature Papers Give Vital Data



Rutherford

Accelerated corrosion of equipment as a result of high temperatures is a serious problem in modern industry. This problem is covered in some of its aspects in the five papers to be delivered during the Elevated Temperature Corrosion Symposium at Chicago. The session will be held from 9 to 12 noon on Wednesday, March 18 at the Sherman Hotel.

J. J. B. Rutherford, of Babcock and Wilcox Tube Company, Beaver Falls, Pa. and G. A. Fritzlen of Haynes Stellite Company, Kokomo, Ind. are chairmen.

Information included in the papers is expected to be very significant to industries concerned with high temperature corrosion.

Biographies of authors and abstracts of the papers follow.

An Investigation of Accelerated Oxidation Due to Vanadium

By F. C. Monkman and N. J. Grant, Massachusetts Institute of Technology, Cambridge, Massachusetts

Forest C. Monkman was born August 7, 1929, in Roselle Park, New Jersey. After moving to Chicago, he attended public schools there. He entered the Massachusetts Institute of Technology in 1947 and received his BS degree in Metallurgy in June 1951. He entered graduate school at MIT in 1951 and received his MS degree in metallurgy in June 1952. He is currently a research assistant in the Department of Metallurgy, and pursuing studies for an ScD degree.

Nicholas J. Grant was born in 1915, in South River, New Jersey. He studied metallurgy at Carnegie Institute of Technology where he graduated in 1938, after which he worked for a number of years at the Bethlehem Steel Company as an open hearth metallurgist. In October 1940, he entered MIT to study for his doctorate degree, which he received in metallurgy in 1944. During the period 1941-1945, he was associated with the research programs at MIT. He became an assistant professor in 1944 and is now an associate professor working both in the fields of physical chemistry of steelmaking and in high temperature behavior of metals. He is married, has three children and resides at Winchester, Massachusetts.

Abstract

The anticipated increase in the use of crude fuel oils containing vanadium in high temperature installations has initiated further experimentation concerning the nature of accelerated oxidation caused by the action of certain oxides of the metals V, Mo and W on heat resistant alloys at elevated temperatures.

The effect of additions of various refractory metal oxides on the physical and corrosive nature of a vanadium oil ash has been investigated to determine the possibility of oxide additives as a method of preventing accelerated oxidation. Oxidation tests were also conducted to determine the effect of some of the major constituents of oil ashes on accelerated oxidation.

Since a solution to the problem of accelerated oxidation may be best accomplished through the knowledge of the oxidation mechanism, chemical analysis and X-ray diffraction studies were conducted on the oxide scale formed during the accelerated oxidation of Type 347 stainless steel in contact with liquid V_2O_5 . The metal-oxide interface was found to have the highest level of oxidation and the highest vanadium concentration. Also at this interface, X-ray diffraction evidence was found for a vanadium-oxygen-metal compound having the formula MVO .

High Temperature Lead Corrosion of Stressed Steel

By H. F. Peters, Lukens Steel Company, Coatesville, Pennsylvania

Henry F. Peters, technical service engineer, Technical Service Department, Lukens Steel Company, has been associated with the organization since 1949. Mr. Peters joined Lukens Research Department as technical assistant in 1949, serving there until he was transferred to Technical Service in 1951. A native of Brooklyn, N. Y., Mr. Peters attended Mississippi State College classes in mechanical engineering and was graduated from Rensselaer Polytechnic Institute with a degree of BS in metallurgical engineering. He also served in the United States Army during World War II, receiving his discharge in 1945 as a first lieutenant.

Abstract

The sudden failure of wrought steel lead kettles used in the temperature range of 1000°-1200° instigated a laboratory investigation of which a portion is covered in this paper. Laboratory examination of samples from the kettles revealed a mode of intergranular cracking originating on the interior surface of the kettle that suggested a possible stress-corrosion mechanism. In order to explore this possibility, laboratory apparatus was designed to permit testing of steel samples under stress in a lead bath at temperatures from 800°-1440° F. The effect of variations in lead bath composition, stress, temperature and microstructure on corrosion and stress-rupture life of rimmed and silicon killed steel specimens is reported in this paper.



Peters

Failure by intergranular penetration was not achieved under the conditions claimed to exist at the time of the kettle failures. However, when the stress was increased to a degree approaching the yield stress of the steel at the temperature of testing, there was marked penetration of the grain boundaries and the resulting time for rupture was very short relative to published values. The higher stress level also promoted spheroidization of the carbides to a greater extent than in specimens tested at the same temperatures, but at a lower stress level.

While many of the questions brought

up in this investigation remain unanswered, it is hoped that they will arouse interest and comments from those concerned with high temperature testing and failures.

Some Notes on the Oxidation Resistance of Boron Containing Chromium-Nickel-Cobalt-Iron Alloys

By W. O. Binder, Electro Metallurgical Company, Niagara Falls, New York and E. D. Weisert, Haynes Stellite Company, Kokomo, Ind.



Weisert



Binder

William O. Binder was graduated from the Case Institute of Technology with degree of bachelor of science in metallurgical engineering in 1931, and received the degree of metallurgical engineer in 1936. He was employed by the metallurgical department of The Dow Chemical Company, Midland, Michigan, from 1931 to the latter part of 1936 engaged in investigative work on magnesium and magnesium-base alloys. In 1936, he joined Union Carbide and Carbon Research Laboratories, Inc., Niagara Falls, New York and in 1940 was placed in charge of research on high chromium steels and alloys for corrosion and heat-resistant purposes. Now he is in charge of the Technical Service and Development Laboratory, Electro Metallurgical Company, Niagara Falls, New York. He has published a number of articles dealing with the properties and corrosion resistance of the stainless steels and has assisted in the development of some of the cast and wrought high-temperature alloys containing cobalt for application in gas turbines. He is chairman of the High-Alloy Committee of the Welding Research Council of the Engineering Foundation and in 1949 was one of the recipients of the Henry Marlowe Howe Medal awarded by the American Society for Metals.

Edward D. Weisert, head of the Technical Data Branch of Applied Research and Development Department of Haynes Stellite Company, Kokomo, Ind., he has been employed by Haynes Stellite since graduation from University of Michigan in 1950. He holds a BS in metallurgical engineering and a BS in chemical engineering. He formerly was employed as research assistant at the Engineering Research Institute, University of Michigan and during World War II was a navigator of combat bombers with the Eighth Air Force based in England. He is a member of ASM and NACE.

Abstract

During an investigation of a series of cast chromium-nickel-cobalt-iron alloys it became of interest to gain some indication of the effect of boron on the oxidation resistance of this family of alloys. A series of alloys containing 18 and 20 percent chromium with various balances between nickel, cobalt, iron and boron were subjected to oxidation tests in air at 1650, 1830 and 2012° F. Temperatures somewhat above those encountered in gas turbine applications were chosen to accelerate the attack since the effect of boron was not readily noticeable at temperatures below 1650° F.

The results of this investigation indicate chromium and nickel to have a beneficial effect on the oxidation charac-

(Continued on Page 30)

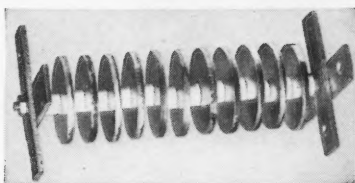
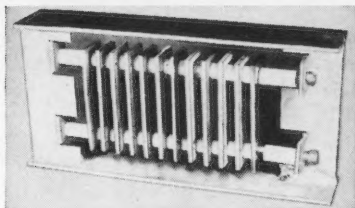
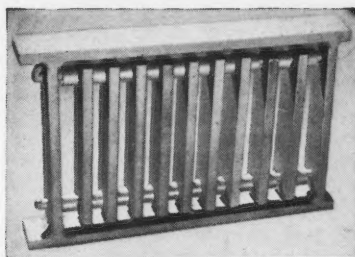
How INCO HIGH-TEMPERATURE ENGINEERS SEEK THE ANSWER TO A PROBLEM

Inco High-Temperature Service is ready to assist you on metal problems at high heat with all its knowledge of high-temperature metal performance.

In laboratories at Bayonne, N. J., and Huntington, W. Va., creep tests measure the load-carrying ability of various alloys at temperatures up to 2100° F.

Other tests are constantly adding to the knowledge of how metals behave under varying degrees of heat and corrosive conditions. These laboratory studies are extended by field work. Investigation of metals serving in high-temperature applications reveals why some metals stand up where others fail. Corrosion is often the most important cause of damage and failures.

In field work Inco Engineers make use of High Temperature Corrosion Test Racks, shown



High-Temperature Test Racks are supplied in different styles or shapes when necessary for placing in the corrosive atmosphere. All are basically a selection of different metals — which are exposed simultaneously to the corrosive conditions.

above, to observe the effects of corrosive atmospheres. These carry a selection of different alloys which are placed right in the existing equipment to give a direct comparison of the various materials under actual service conditions.

After removal, the samples of various alloys are examined. The suitability of the alloys or the degree of damage is evaluated from the appearance of scale, the depth of attack, and other data derived from metallographic study and mechanical testing.

In your high-temperature problems, whether in present activities or in new projects, Inco High-Temperature Engineers will be glad to work with you. Let them send you the High-Temperature Work Sheet . . . to aid you in explaining your problem. Then see if Inco Engineers cannot help solve your difficulty.

HIGH TEMPERATURE WORK SHEET

A simplified form to describe the corrosion problem for study and suggestions

Send for your copy of this new High-Temperature Work Sheet; it simplifies gathering the full story of your problem.

THE INTERNATIONAL NICKEL COMPANY, INC.
DEVELOPMENT AND RESEARCH DIVISION
67 Wall Street - New York 5, N. Y.



THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

Elevated Temperatures—

(Continued From Page 28)

teristics of these alloys. Iron and boron and, to a lesser extent, cobalt were found to have an adverse effect on the oxidation resistance. Molybdenum strongly decreased the alloys' resistance to oxidation. Carbon and tungsten have no apparent effect at the levels investigated.

It was concluded that while boron has an adverse effect on the oxidation resistance of chromium-nickel-iron-cobalt alloys, boron-bearing alloys may be designed which have oxidation resistance comparable to those without boron by proper control of composition. This may be accomplished primarily by keeping

the iron content below 6 percent and through the use of tungsten rather than molybdenum as a minor addition for strengthening purposes.

Corrosion by Aqueous Solutions at Elevated Temperatures and Pressures

By F. H. Beck and M. G. Fontana, Ohio State University, Columbus

Franklin H. Beck assistant director of the Corrosion Research Laboratories at the Ohio State University, Engineering Experiment Station. Dr. Beck received his BS in metallurgical engineering from the Pennsylvania State College and did graduate work for an MS and PhD in metallurgy at the Ohio State University under the supervision of Professor M. G. Fontana. His graduate work was concerned with corrosion and passivation studies of 18-8 stainless steel. He was employed by the E. I. du Pont de Nemours & Company for two years before entering the graduate school at Ohio State.

Abstract

Recent trends in the chemical industry are in the direction of higher temperatures and pressures. Few data are available in the literature on corrosion of metals and alloys at temperatures above the atmospheric boiling points of the solutions. This paper presents data on the corrosion of a variety of metals and alloys by nitric, phosphoric, acetic, sulfuric acids and sodium hydroxide at temperatures up to 425° F. The metals and alloys include CF-8 (18-8S), CF-



Beck

8M (18-8SMo), Durmet 20, 18 percent chromium steel, cast iron, nickel, titanium, Duriron and some of the very high alloy materials.

In general, corrosion increases rapidly as the temperature is raised above boiling and in some cases very rapid and previously unexpected attack occurs. Some data at lower temperatures are included for comparison.

Data are also presented on the inhibiting effects of metallic ions in solution and in some cases spectacular decreases in corrosion rates are observed. An example is the effect of copper ion on corrosion of stainless steel by phosphoric acid.

Sub-surface corrosion of stainless steel by hot caustic is described. Borderline passivity effects in hot acids are discussed.

Equipment for conducting corrosion tests at elevated temperatures and pressures is described.

Porcelain Enamels and Ceramic Coatings, Prime Inhibitors of Metal Corrosion

By D. G. Bennett, University of Illinois, 204 Ceramics Building, Urbana, Illinois

Dwight G. Bennett received a BS degree in ceramic engineering from the University of Illinois in 1930 and did some subsequent graduate work at the University of Pittsburgh. His professional record includes some work at the Geo. D. Roper Corp., the A. O. Smith Corp., Metal and Thermit Corp., 1930-31, Mellon Institute, 1931-43. Since that time he has been research professor, Department of Ceramic Engineering, University of Illinois. He has been chairman of the Enamel Division, American Ceramic Society, chairman of the Pittsburgh and Chicago Sections of the American Ceramic Society.

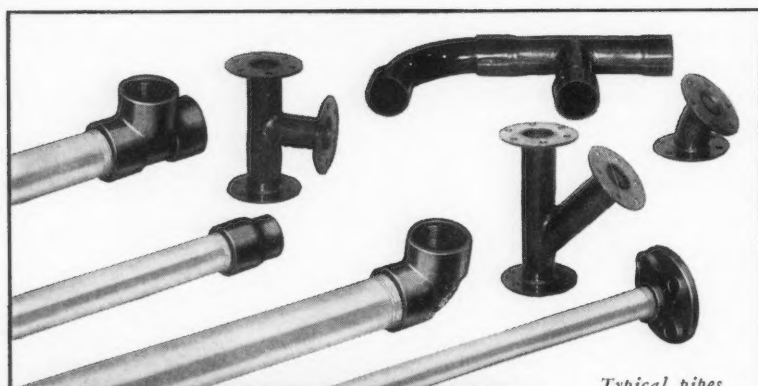
He is a member of Sigma Xi, Tau Beta Pi, Sigma Tau and a member and former national president of Keramos, Honorary Ceramic Engineering Fraternity. He is co-holder of several U. S. patents in the field of high temperature resistant ceramic coatings.

Abstract

Some of the pertinent background of present day developments in protecting metal from corrosion by means of ceramic coatings is reviewed. Test methods are presented and the evaluation of selected tests discussed. Some examples of coating effectiveness and areas in which coatings could be used to advantage are presented.



Bennett



Van Dorn

Typical pipes and fittings of nonplasticized polyvinyl chlorides fabricated to specifications by Van Dorn.

INDUSTRIAL PLASTICS OFFER YOU—

- ✓ High Resistance to Acids & Alkalies
- ✓ Tensile Strength of Aluminum, with one-half its weight
- ✓ Readily Formed, Machined, Drawn Molded, or Welded

AVAILABLE FORMS

SHEETS $\frac{1}{32}$ " through 1"

PIPE $\frac{1}{2}$ " through 6" diameter (10 ft. lengths)

ROUND BARS $\frac{1}{4}$ " through 2" diameter (10 ft. lengths)

WELDING ROD $\frac{1}{8}$ " and $\frac{3}{16}$ " diameter

TYPICAL APPLICATIONS

Van Dorn fabricates its rigid nonplasticized polyvinyl chlorides into such products as: Ducts, Hoods, Chemical Tanks, Tank Liners, Plating Racks, Fume Stacks and Piping.

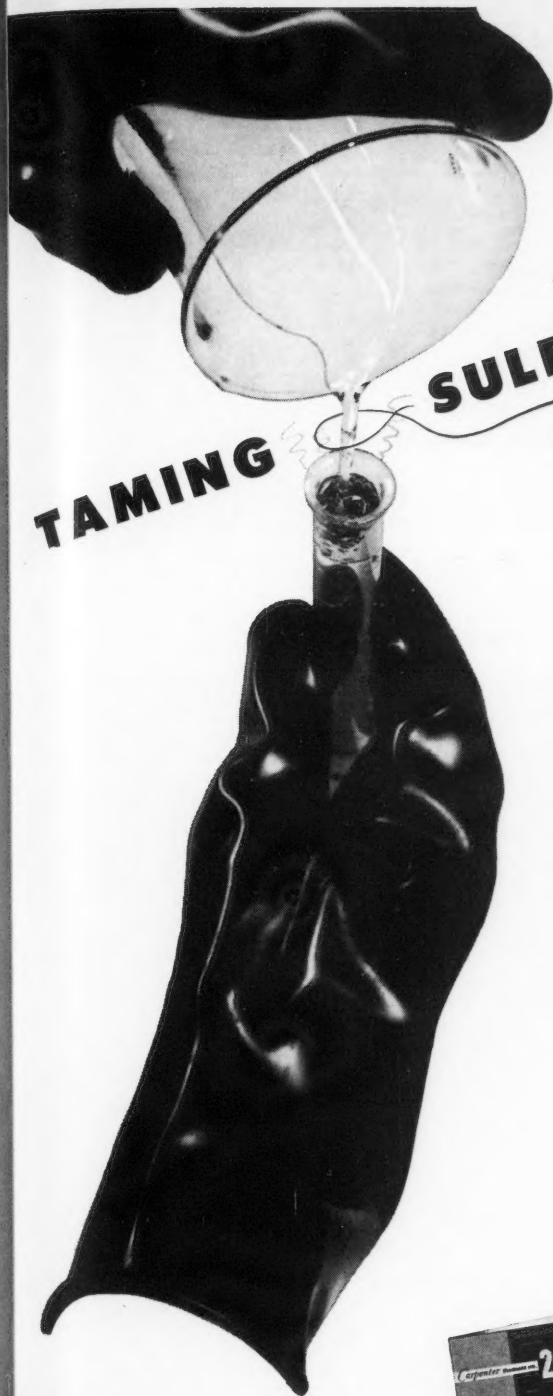
WRITE FOR ILLUSTRATED BULLETIN AND SPECIFICATIONS

INDUSTRIAL
PLASTICS
DIVISION

THE VAN DORN IRON WORKS CO.

2685 East 79th Street

Cleveland 4, Ohio



TAMING SULPHURIC ACID

with a Super Stainless Steel



- The battery filling nozzle shown at the right was made of good 18/8 stainless steel... but this is the way it looked after only a two week beating from 12% sulphuric acid!



The battery manufacturer had a real headache on his hands. Hard rubber nozzles used previously resisted the acid but broke easily, sometimes as high as 10 per day. And when a nozzle broke, it tied up the production line 30 minutes or more.

Then he solved his problem by changing to nozzles made from Carpenter No. 20—the super stainless steel that handles sulphuric acid and a host of other strong corrodents. The left photo shows a Stainless No. 20 nozzle after five months' use. There is no sign of corrosion.

If you have a product or a process where corrosion is a problem, put Carpenter experience to work for you. Distributors are located in major cities from coast to coast. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y., "CARSTEELCO"

New 16-Page Book of Technical Data

For complete information on No. 20 and the jobs it can do, write us a note on your company letterhead and ask for the new Carpenter Stainless No. 20 book.



Carpenter

STAINLESS TUBING & PIPE



- guaranteed on every shipment



Small Groups Will Discuss Pipeline Corrosion

Conference Registration Will Open March 15

Registration for the Ninth Annual Conference and Exhibition will open at noon, Sunday, March 15 and will be open daily from 8 am to 5 pm at Hotel Sherman until 5 pm March 19.

At the registration table identification pins, copies of the official conference program, meetings schedule, ladies program tickets, banquet tickets and information concerning the meeting will be available.

Official Program

Copies of the official conference program will be available at the registration desk and at the NACE booth on the exhibit floor. This program gives full information about all the events of the conference except committee meetings, which are scheduled separately. The program will include floor plans of the exhibit area and meeting room area, as well as indices to the exhibits and a classification of exhibits by products exhibited.

Information concerning all social events and the ladies program will be indicated also.

Experienced Pipeliners Available to Aid in Round Table Groups

Simultaneous meetings by small groups of pipe liners for discussion of their mutual problems have been planned

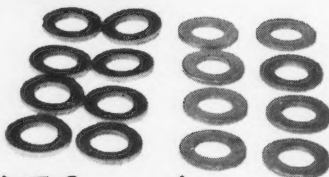
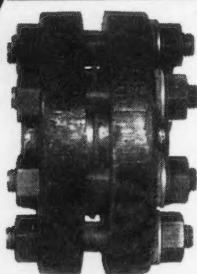
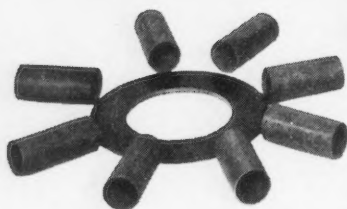
for the Pipe Line Group Discussion session at the Chicago Conference. The meetings, to consist of up to 30 persons, will be held from 9 to 12 a.m. Wednesday, March 18. This session is under the direction of A. L. Stegner, with Tennessee Gas Transmission Company, Houston. Mr. Stegner has secured the assistance of several leading pipe line engineers who will be available for answers when needed.

This type of discussion is believed to be a more fruitful one than that including a large group of persons. Similar discussion groups were pioneered successfully at the October, 1952, meeting of South Central Region NACE at New Orleans.

The small groups will make it possible for every one present to ask questions and participate in the proceedings if he wishes to do so.



Stegner



**for PIPE NIPPLES and
PIPELINE FLANGES**



WRITE FOR VALUABLE, NEW BULLETIN

For a period of 12 years the Nelson Electric Manufacturing Company has been furnishing Phenolic Insulating Materials for pipe nipples and the insulation of pipeline flanges. We introduced the use of thin-wall tubing sleeves for insulating the studs in standard flanges, without requiring re-drilling of the flange and providing smaller studs. We now offer flange insulation, packaged for immediate shipment on the more common sizes.

Write for new, 10-page bulletin which describes our Insulating Materials.

NELSON Electric MANUFACTURING CO.

217 N. Detroit St.

TULSA, OKLAHOMA

Telephone 2-5131

MIT Fellowships to Executives Available

Fellowships for study at Massachusetts Institute of Technology in the school's Executive Development Program covering one year of advanced study in industrial management have been announced. One of the Sloan fellowships, the course will be given to young industrial executives who have already demonstrated their ability to grow into major management responsibilities and who are assured of opportunities for constructive leadership in their companies.

A nationwide competition for fellowships to the program will close on February 21, 1953. The year's study is devoted to fundamental problems of business enterprise. Labor relations, the interrelationship of government and industry, domestic and international economy, sociological development and the role of the company in the nation's industrial economy and social structure will be considered. Address of Massachusetts Institute of Technology is Cambridge 39, Mass.

General Business Meeting

The general business meeting of the association, to be held beginning at 11 am on March 17 is expected to include reports from chairmen of all standing committees of the association. Outgoing officers also usually give reports of the association's work for the past year.

Announcing—

your new and
better source of
high purity...



magnesium anodes



Pipeline Anode Corporation's uniform quality AN-SPEC magnesium anodes are the result of years of experience in the research, development and practical application of magnesium as a means of arresting corrosion of metallic structures. New features which make AN-SPEC anodes your best buy are:

1. Cylindrical Shape gives higher efficiency—longer life
2. Guaranteed High Purity—spectrographic analysis furnished with all anodes
3. Backfill Specially Compacted to assure anodes remaining centered in the fill
4. Minimum Delay in supplying any size or shape anode required.

To aid in your selection and use of AN-SPEC anodes, Pipeline Anode Corporation offers a complete counseling, engineering and installation service. Write today for further information or advice on the use of AN-SPEC anodes.

AN-SPEC anodes manufactured by Magnesium Division of M. J. Crose Manufacturing Co., Inc.

PIPELINE *Anode* CORPORATION

25th WEST AVENUE AND SAND SPRINGS ROAD

P. O. BOX 996

TULSA, OKLAHOMA

DISTRIBUTORS:

PIPELINE SUPPLY COMPANY
2230 Magnolia Street
Birmingham, Alabama

PROTECTO WRAP COMPANY
436 Douglas Blvd.
Los Angeles 12, California

Power and Communication Session Has 4 Papers

Station pumps, copper-jacketed cable, rectifiers and cable sheath corrosion will be covered in four papers to be given during the Power and Communication Industry Symposium at Chicago. The session, to be held from 2 to 4:30 p.m. Wednesday, March 18, at the Sherman Hotel, is expected to attract engineers concerned with power station and distribution corrosion problems.

Chairmen are C. H. Fellows and W. D. Sanderson, Detroit Edison Co., and R. M. Lawall, American Telephone & Telegraph Co., Cleveland.

Materials for Central Station Pumps

By J. B. Godshall, Ingersoll-Rand Company, Phillipsburg, New Jersey

J. B. Godshall was born in Perkase, Pennsylvania, July 7, 1907, attended Muhlenberg College and taught in public elementary school until starting in the analytical laboratory of Ingersoll-Rand Co. in 1926. He became chief chemist in 1930 and since 1941 has been metallurgist for the Cameron Division of Ingersoll-Rand Co. One of his responsibilities is materials engineering for pumps as related to their corrosive environments.

He is a member of the American Chemical Society, American Society for Metals, National Association of Corrosion Engineers, and American Society of Lubrication Engineers. He has been active in committee work for Hydraulic Institute, Compressed Air and Gas Institute and American Society for Testing Materials. He is a past president of the Engineers' Club of the Lehigh Valley and has served on numerous committees for the Lehigh Valley Chapter of the American Society for Metals.

Abstract

Increased temperature, pressure and purity of central-station feedwater caused corrosion-erosion in feed pumps. Studies by operators, pump manufacturers and technical groups have led to certain conclusions: First, reducing corrosion by modifying the water is rarely feasible. Second, materials must be used which resist corrosion-erosion. Third, cast iron and carbon steel are generally unsuitable. Fourth, 5 percent chromium steels prevent corrosion-erosion but higher alloy concentrations do not provide a marked improvement. Relative service life is about 1 for iron and steel, 10 to 90 for 1 percent chromium steel, 100 for 5 percent chromium steel, 100 to 105 for 13 percent chromium steel and 100 to 150 for 18/8. General use of chromium steels present manufacturing problems because clearances must be adjusted and different materials and/or hardnesses are important to prevent seizure. Preheating and stress-relief annealing are important after welding. Stainless on "K" monel shafts are recommended.

Heater drip pumps need all-bronze or 13 percent chromium steel construction if dissolved gases are present. If there is no contamination, or if the temperature is low as in the case of condensate pumps, iron or steel casings with bronze impellers are used. Circulating pump materials vary with the water quality



Godshall

with cast iron casings and bronze impellers are typical for fresh water. For sea and harbor waters all-bronze construction is desirable. With polluted harbor waters, stainless steel impellers in bronze casings are sometimes necessary. Commercial considerations sometimes dictate the use of cast iron casings for very large circulating pumps. For the corrosive applications, Monel or stainless shafts are recommended to prevent failures by corrosion fatigue.

Polarization Effects and Current Loss on Copper-Jacketed Telephone Cable Buried in Salt Lake Bed Area

By Daniel R. Werner, American Telephone & Telegraph Company, Kansas City, Mo.

Daniel R. Werner is in charge of cable corrosion control engineering, Western Area, American Telephone and Telegraph Company, Kansas City, Missouri. Has been in electrolysis work on telephone cables since 1934. He is an engineering graduate of Rose Polytechnic Institute, Terre Haute, Indiana.

Abstract

Cathodic protection has been applied to a copper jacketed cable in a salt lake bed about one mile wide in which the earth resistivity was apparently uniform at about 20 ohm-centimeters. Current of about one ampere flowed on the copper jacket into the low earth resistivity lake bed area from the higher earth resistivity areas on either side and was found to be sustained by polarization effects when the cathodic protection current was removed. The current loss on the copper jacket was found to be concentrated in an area about 720 feet wide, 360 feet each side of the point where the cathodic protection current had been drained from the copper jacket. The copper jacket to soil potential tested most negative to a copper sulfate half cell in the 720-foot area where the current loss was concentrated and was of the order of -1.0 to -1.1 volts. Permanent remedial measures will consist of installations of magnesium anodes distributed throughout the low earth resistivity area and insulating joints in the copper jacket at locations where large changes in the earth resistivity occur.



Werner



Fellows



Sanderson



Lawall

Use of a Magnetic Amplifier in a Controlled Rectifier for Cathodic Protection of Underground Metallic Structures

By Oliver Henderson, Ohio Bell Telephone Company, Cleveland

Oliver Henderson graduated in electrical engineering from Case Institute of Technology in 1922 with a BSEE degree. He obtained his EE degree from Case in 1943 for his work on carrier telephone systems on cable conductors. He has been engaged in engineering work at The Ohio Bell Telephone Company since graduation, originally in the Plant Department and later in the General Engineering Department as Foreign Wire Relations Engineer. His work includes the coordination of structural, inductive, protection and electrolysis problems involving telephone company plant and that of the other utilities.

He is a member of the Cleveland Electrolysis Committee which is composed of representatives from the twelve major utilities operating in Northern Ohio.

Abstract

This paper covers the initial attempt of the part of the Ohio Bell Telephone Company to use a magnetic amplifier to give continuous control of the output of a copper-oxide rectifier used for cathodic protection of underground lead covered cables.

The controlled rectifier was designed and built for use at a location where stray current "end effects" were damaging underground telephone cables and municipal light cables and were threatening high pressure water mains.

When properly adjusted, the output of the rectifier will increase or decrease automatically so that at each instant the amount of forced drainage will be adequate to protect the underground telephone cable sheath but will not be in excess of the value at which neighboring underground metallic structures would become anodic and would thus become subject to corrosion.

For satisfactory operation the amplifier had to be designed to give a large gain so that a change in the control voltage of only .4 volts ($+2$ to -2 volts) would be sufficient to vary the output of the rectifier from practically zero current to full rating. In the installation described in this paper the gain of the magnetic amplifier is in the order of 12,000.

The magnetic amplifier type of control (Continued on Page 35)



Henderson

Power, Communications— (Continued From Page 34)

trol is well suited to outdoor installations where subject to wide changes in temperature and at remote locations where frequent maintenance inspections are not feasible.

The magnetic amplifier has advantages over other available control devices which accomplish this same purpose in that it has no moving parts, no vacuum tubes, batteries, motors, relays or contactors. The magnetic amplifier gives a continuous output control which is superior to the stepped increment changes that result from relay or contactor operation.

Cable Sheath Corrosion and Prevention

By B. B. Reinitz, Okonite Callender Cable Company, Inc., Paterson, New Jersey

B. B. Reinitz, Chief Chemist and Metallurgist, Okonite-Callender Cable Co., Paterson, N. J., has been engaged continuously since 1925 in research and development of non-ferrous metallurgy and dielectrics for high voltage cables also in the prevention of corrosion to metallic cable sheaths. He was associated as analytical and research chemist with Okonite Co., Passaic, N. J., following his graduation in 1916-1917 from Cooper Union with a degree of BS in chemistry. He is a member of American Chemical Society and National Association of Corrosion Engineers and is chairman of NACE TP-16B—Corrosion of Lead and Other Metallic Cable Sheaths.

Abstract

Two thirds of cable failures are attributable to corrosion and mechanical damage. Replacement costs and service interruptions are considerations of prime importance. Conservation of our limited metal resources is an additional reason for seeking improved methods of preventing corrosion.

While stray current corrosion has decreased in recent years, galvanic and concentration cell corrosion have multiplied. Also, other causes of corrosion, such as microbiological action, scoring, de-icing by means of salts, electroendosmosis, cement are proofing and alternating current, are receiving increased attention.

Cathodic protection, when used for cable sheathing, serves primarily as a means for mitigating rather than for completely eliminating corrosion, and its applications are limited. On the other hand, a suitable covering over the lead sheath offers a dependable and more certain method of protection for underground cables.

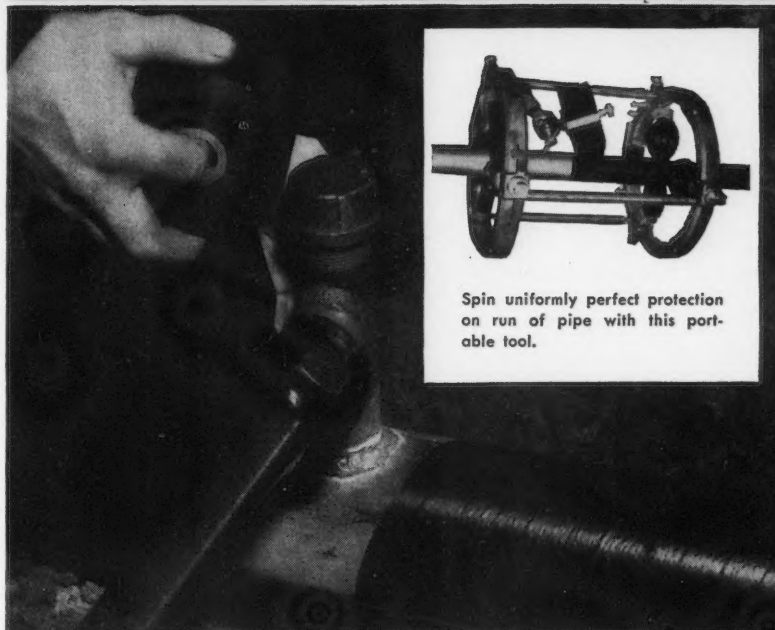
Nearly twenty years of service experience without a recorded case of sheath corrosion have established the value of a thermosetting covering having a fiber-free, homogeneous wall of properly compounded neoprene. Recently adopted manufacturing methods have led to an improved covering, possessing a more uniform wall thickness, greater density and freedom from laminations.

Reprints of technical material printed in Corrosion are not made except on special order. A limited number of reprints of especially interesting material is made on occasion.



Reinitz

TRY DRESSERTAPE*



Spin uniformly perfect protection on run of pipe with this portable tool.

Fast, easy, effective CORROSION PROTECTION!

No matter who does the job, *all* your underground pipe and joints can now have *full, permanent protection* against corrosion. Dressertape—the high dielectric plastic tape—is the answer. Any crew can master the easy application techniques in minutes, save expensive man hours and cut over-all costs on every job. Try Dressertape yourself!

LOOK AT THESE OUTSTANDING DRESSERTAPE ADVANTAGES!

- Uniform coating—top, bottom and sides.
- Easy, clean to apply—sticks at a touch, no heating equipment required.
- Safe to use—no burns, no fumes.
- Conforms to irregular surfaces—especially over fittings on service lines.
- Immediate backfill—no waiting.
- Exceptional electrical properties—dielectric strength: 10,000 volts; insulation resistance: 100,000 megohms.
- Lasting protection against water, oil and soil chemicals—equal to, or exceeding, yard or mill-wrapped pipe.
- Available in widths from 3/4" to 6".

Send today for our new, fully illustrated booklet "Dresser Taping Fundamentals". Anyone can master Dresser's laboratory and field proved methods in minutes.

*Dressertape is a trade-mark of Dresser Manufacturing Division

DRESSER
MANUFACTURING
DIVISION

59 Fisher Ave., Bradford, Pa.
(One of the Dresser Industries)
SALES OFFICES:
New York, Philadelphia, Chicago,
Houston, S. San Francisco. In Canada:
629 Adelaide St., W., Toronto, Ont.

Well Inhibitors, Casing Corrosion Are Topics

Three papers, one on laboratory methods for evaluating inhibitors, one on corrosion in sweet oil wells and the third on corrosion of casings are to be given during the Oil and Gas Production Symposium at Chicago. The symposium, to be given from 2 to 4.30 p.m. on Wednesday, March 18, has as its chairmen H. L. Bilhartz of Atlantic Refining Company, Dallas, and R. C. Buchan of Humble Oil & Refining Co., Houston.



Buchan

Biographies of authors and abstracts of papers follow.

Laboratory Methods for the Evaluation of Inhibitors for Use in Oil and Gas Wells

By E. C. Greco, United Gas Corporation, Shreveport, La., and J. C. Spalding, Sun Oil Company, Dallas, Texas



Spalding



Greco

J. C. Spalding, Jr., attended Texas A&M College and Georgia School of Technology and received a BS in Basic Engineering from the latter in 1945 and a Bachelor of Chemical Engineering in 1946. He spent one year teaching on the staff at Southern Methodist University and joined Sun Oil Company as a drilling fluids engineer in 1947. He presently is employed by Sun Oil Company, Southwest Division as materials and equipment engineer. He is a past member AIChE and ACS, and presently a member of the NACE and the API and chairman of the North Texas Section of the NACE.

Abstract

The need for a compilation of the various methods used for laboratory evaluation work on oil and gas well corrosion inhibitors was recognized at the national meeting of the NACE in 1952. At that time, the chairman of TP-1 appointed the authors as a committee to contact those companies, both producing and chemical manufacturing companies, known to be interested in the problem of oil and gas well inhibitors. Consequently, inquiries were sent out to all of the major producing companies that were members of NACE and several of the chemical manufacturing companies that were known to be working on the development of oil and gas well corrosion inhibitors. As a result, methods used by some ten major producing companies and four chemical manufacturing companies along with methods used in one of the research departments of a university were gathered. The general classification of tests used in the laboratory are presented along with some meager information as to the correlation

tion of such tests with field experience.

The short range purpose of this particular paper is to present to all those interested in the problem, the possible methods that may be used in the laboratory for such evaluation work and at the same time to solicit from all those receiving this report any information that may lead TP-1 to the adoption or, at least, recommendation of standardized laboratory procedure. The latter action, of course, is the long range purpose of this work.

Present data gathered from the above mentioned companies indicates the majority working in this field still rely upon corroding systems as set up in the laboratory (whether reflecting field conditions or entirely synthetic) to produce weight loss upon coupons made from material expected to be used in the field. In addition, there are a few companies working on such varied methods of laboratory evaluation as the determination of: 1) film resistivity, 2) hydrogen evolution, 3) drop size ratio, etc.

Corrosion in Sweet Oil Wells

By Howard E. Greenwell, The Atlantic Refining Company, Dallas, Texas

Abstract

It has been known for a number of years that corrosion problems occur in the operation of sweet oil wells. General recognition of this fact has been brought about recently as a result of concerted efforts of the NACE TP-1 Committee. It is the purpose of this paper to summarize the present understanding of sweet oil well corrosion problems and to discuss means of detection and control. The greater part of the data which support the views given in the paper have been collected by the TP-1C Subcommittee on sweet oil well corrosion and by various individuals associated with the TP-1 committee work.

It has been established that two distinct types of corrosion occur in sweet oil wells. One type, which has been known as "high pressure corrosion," occurs in wells producing as little as 0.1 percent water. The other type usually occurs in lower pressure wells and its incipience depends on water production. This paper considers both types of sweet oil well corrosion with regard to the causative agents, controlling physical factors, statistics of occurrence and severity and control measures. Emphasis is placed on the most recent developments in the studies of "low pressure" or water dependent type of sweet oil well corrosion.

Corrosion of Casing in Oil and Gas Wells

By Jack L. Battle, Humble Oil & Refining Company, Houston, Texas

Abstract

In January, 1952, there were 482,260 producing oil and gas wells in the continental United States, having an average depth of 3888 feet. Assuming 7-inch OD 29-pound casing, these wells were equipped with approximately 27 million tons of steel in the oil string, having a present-day replacement cost of about \$5,000,000,000. These wells should produce crude oil reserves estimated at 26 billion barrels plus some 4.5 billion bar-

rels of natural gas liquids.

A limited polling of companies participating in NACE Committee TP-1H activities indicates that in fields in which only 45,830, or less than 10 percent, of these wells are located, repair of casing due to corrosion failure is costing these companies in excess of \$2,000,000 annually at the present time. This is exclusive of loss of production due to downtime, premature abandonment of isolated wells and factors of a less tangible nature. Obviously, the total loss to industry is great and can only be estimated.

This paper discusses the various causes of such corrosion failures, the presently used methods of repair, and preventive measures currently being practiced. The results of a survey of one operator's experience over a 10-year period is drawn upon in some detail.

New Porcelain Enamel Coatings Are Valuable

Newly developed porcelain enamel coatings will be valuable aids to the solution of corrosion and heat problems, in the opinion of W. A. Barrows, newly elected president of the Porcelain Enamel Institute.

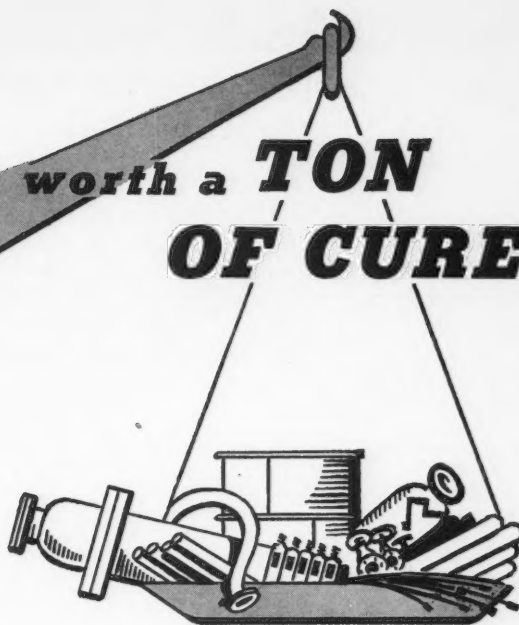
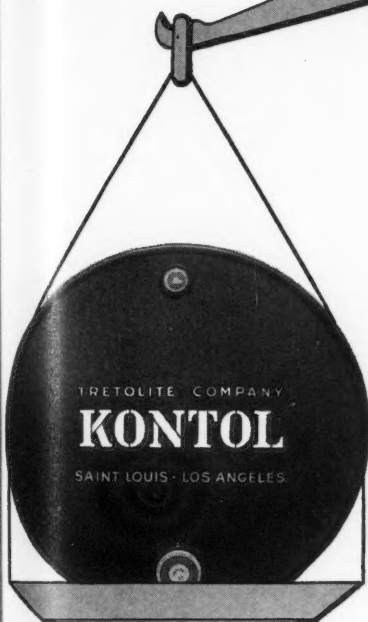
There are hundreds of different ceramic coatings, according to Mr. Barrows and the selection of the proper coating depends on its end use. Prolonged operation under high temperature and the application of high stresses will require the selection of the proper base metal as well as the proper coating. Acid resistance, dielectric characteristics and resistance to thermal shock also are important factors for consideration, their importance varying with use conditions.

One of the advantages claimed for the use of porcelain enamels is the wide availability of raw materials. This eliminates the problem presented by scarce and expensive metals and alloys. It is claimed that almost any ceramic coating can be supplied readily at a relatively low cost and that even the expensive mixtures more than justify their use because coatings are spread thin and the enamel prolongs greatly the life of parts to which the enamel is applied. Certain frits (the raw porcelain enamel mixture) cost as much as two dollars a pound. Most frits cost about ten cents a pound.

Much of the research progress in developing high temperature porcelain enamel is the result of the need for jet engines. Whereas ordinary porcelain enamels are limited to sustained use at temperatures of less than 1000 degrees F, the high-temperature ceramic coatings generally can be used at temperatures of 1600 to 1800 degrees F for long periods, corrosion and mechanical factors being normal.

Generally, according to Mr. Barrows, there are two groups of porcelain enamels and ceramic coatings: 1) regular, for use only under normal atmospheric conditions and with solutions that are normally free from acids and alkalis, and 2) acid resistant, which are resistant to most acids except hydrofluoric acid. The problem of alkali resistance of porcelain enamels is somewhat similar to that of acid resistance.

A BARREL OF PREVENTION is worth a TON OF CURE



Especially when the "CURE" for corrosion damage usually requires tons of hard-to-get steel to replace corroded-out production or refinery equipment.

KONTOL inhibitors prevent corrosion damage by forming a tightly-adsorbed, impervious film at metal surfaces. This Kontol film effectively protects pumps, rods, tubing and flow lines in the field and is being successfully applied in refineries to combat severe corrosion problems. If you have corrosion troubles, get in touch with your Tretolite field engineer, today.

TRETOLITE COMPANY

St. Louis 19, Missouri • Los Angeles 22, California

CORROSION INHIBITING • DEHYDRATING • DESALTING •
WATER DE-OILING • SCALE PREVENTING • PARAFFIN REMOVING

Four Cathodic Protection Papers Are on Program

The Cathodic Protection Symposium at Chicago during the March 16-20 NACE Conference and exhibition, will consist of four papers. They will be presented from 9 to 11:30 a.m. on Thursday, March 19. E. P. Doremus, of Cathodic Protection Service, Houston, is chairman of the symposium.

Biographies of authors and abstracts of papers are given below.



Doremus

Comparison of Standard Methods of Determining Protection

By Kirk Logan, Cast Iron Pipe Research Assoc., Washington, D. C.

Kirk H. Logan, research engineer with the Cast Iron Pipe Research Association of Washington, D. C. has been engaged in corrosion work 33 years, for many years of which he was Chief, Underground Corrosion Section, National Bureau of Standards. He has published numerous papers on corrosion of pipe underground. His present work is experimenting with methods to prevent corrosion. He is a Fellow and Life Member of The AIEE, and has been a member of NACE since its organization. He also is a member of numerous other technical societies and has received many honors, including the 1951 Speller Award.



Logan

Cable System Design for Cathodic Protection Rectifiers

By R. M. Wainwright, University of Illinois, Urbana

Abstract

The design of any current-carrying cable system involves certain basic factors, which may be listed briefly as follows: a) Ability to meet mechanical stresses, and other environmental requirements, b) Ability to meet voltage attenuation limits, c) Ability of the insulation to withstand applied voltages, d) Ability to meet limitations on current due to temperature and insulation stability, e) Conformance to Kelvin's Economic Law, f) Conformance to legal codes, safety rules, and similar requirements.

The importance of each of the above six factors is discussed in the light of cathodic protection requirements and installations. Emphasis is placed on cable systems which connect the direct current output terminals of the rectifier to ground beds and to the protected metal structures.

Frequently engineers disregard one or more of the six factors in designing cathodic protection cable connections. For example, the tendency is to design to fit the current-carrying capacity of cables as set forth in the various handbooks and to neglect a consideration of Kelvin's Law, which shows that the choice should be toward much larger cables and lower current densities. Also cables which are buried underground are

subject to concentrated electrochemical attack and the type of insulation becomes important. Ordinary insulations may not be sufficient and the normal voltage ratings may be unimportant.

A method of determining annual fixed costs of cables is outlined, and charts are given which enable the engineer to balance fixed charges against cost of losses and thus select the optimum cable size based on economy. Consideration is also given to the effect on the economic picture of selecting cable sizes somewhat off of the theoretical optimum.

The Cathodic Protection of Sea Water Condensers

By R. W. Stetson, The Dow Chemical Company, New York City

R. W. Stetson, attached to the New York office of The Dow Chemical Co., he is engaged in cathodic protection sales. He is a member of the Society of Marine Port Engineers, New York, a member of the National Association of Corrosion Engineers and a graduate of the Officers' Training School, U. S. Maritime Commission. Recent assignments included that of being Project Engineer for the installation of magnesium anodes to cathodically protect the hull of the S. S. Marine Chemist.

Abstract

The practical manner in which magnesium anodes have been used to combat corrosion in condensers cooled by sea water is discussed. Condensers aboard ship and ashore are considered. Fundamental design data based on normal anode circuit resistance in sea water are included and the manner by which this design can be improved by increasing the anode circuit resistance is discussed.



Stetson

Discussion Procedure For Sessions Given

As in prior years an effort will be made to collect a record of discussions so written versions may be obtained for publication in the NACE official publication "Corrosion." A form will be provided on which discussors will be asked to enter information by means of which a written discussion can be solicited later, or on which they may write their discussions at once.

Discussions are collected and sent to authors for reply and, when possible, published at the time the technical paper to which they refer is published. Those secured after publication of the technical paper to which they refer are included in later issues.

Official Photographer

An "Official Photographer" will be designated for the conference. The services of this photographer will be available to all persons at the conference at his standard fees.

Cathodic Protection and High Resistivity Soil

By H. C. Van Nouhuys, Southeastern Pipe Line Company, Atlanta, Georgia

Herbert C. Van Nouhuys, engineer with Southeastern Pipe Line Company, has been engaged in various engineering phases of pipe line construction, operations and maintenance since 1939, and has devoted full time to pipe line corrosion for the last six years. He received a BS degree in electrical engineering from The University of Michigan in 1934, after which he spent several years as a test, applications and research engineer in the heating, air conditioning and refrigeration field. During World War II he held assignments with the Signal Corps and Air Corps as a Training Center Staff Officer and (after electronics training at Harvard, MIT and the Southern Signal Corps School) as a Technical Officer at Ground Radar Research and Development Laboratories. A former member of AIEE, ASH & VE, and the Engineering Society of Detroit, he is now a regional officer of the National Association of Corrosion Engineers.

Abstract

A two-part report of Southeastern Pipe Line's cathodic protection system; Part One deals with a 25-rectifier system from Port St. Joe, Florida, to Atlanta, Georgia, which lowers the pipe-to-soil potential a minimum of .3 volt based on the remote electrode criterion. The pipe line consists of 320 miles of bare and 40 miles of coated 8-inch products line. Design, installation and economic aspects of cathodic protection in the ultra-high resistivity soils encountered are presented.



Van Nouhuys

Part Two deals with comparative tests made between a 301-anode installation having 50-foot spacing and 2-rectifier installations in the somewhat lower resistivity soils between Atlanta and Chattanooga, to determine which was the optimum method to be used for the 120-mile balance of the pipe line. Results indicated rectifiers had an average current density advantage over anodes of 6.4 to 1 and a cost advantage of 1.38 to 1. The minimum current density supplied by the rectifiers was greater than the average density created by the anode system. While realizing that anodes are not recommended for these very high resistivity soils the possibility existed that anode spot protection using 25-foot spacing might be economically favorable when compared with solid rectifier protection. Test procedure, data and economics of both methods are presented.

Pipe Line Safety Code

A safety code for gas pipe lines and distribution systems covering material design, fabrication, installation, testing and operation has been approved by the American Standards Association, 70 East 45th St., New York 17, N. Y. Known as Section 8 of the American Standard Code for Pressure Piping, B31.1c-1952, it is a consolidation of those parts of the existing code for pressure piping that apply to gas piping. The American Society of Mechanical Engineers is sponsoring organization for the section.



Fit Tenite plastic pipe with a saw, slip-sleeve joints, cement and brush

Fitting and laying tough Tenite plastic pipe is quick and easy. For example, the pipe is sawed to size, solvent cement is applied to the pipe ends and a thinner to the slip-sleeve coupling; the two ends are then forced into the slip-sleeve coupling to form the joint. In a typical installation, three men easily laid 4000 feet of 4" Tenite pipe in a day; usually eight men are required to lay the same amount of steel pipe.

Extruded of Eastman cellulose acetate butyrate plastic, Tenite pipe offers unusual corrosion resistance to sour crudes, salt water and electrolytic action.

Because of Tenite's extra-smooth walls, no installation has ever clogged due to paraffin. And for any given head loss Tenite pipe delivers approximately 40% more fluid than clean steel pipe of the same diameter.

Tenite pipe is made by various companies to which Eastman supplies the plastic compound. Send the coupon for our descriptive booklet and list of Tenite pipe suppliers. If you need assistance in adapting Tenite pipe to your operation, our technical staff will be glad to help.

For corrosion resistance ask for PIPE MADE OF—

TENITE

an Eastman plastic



• EASTMAN CHEMICAL PRODUCTS, INC.
Sales representative for
TENNESSEE EASTMAN COMPANY
Division of Eastman Kodak Company
KINGSPORT, TENNESSEE

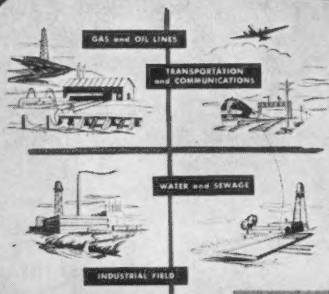
EASTMAN CHEMICAL PRODUCTS, INC.
DEPT. 2, KINGSPORT, TENNESSEE

Please send me further information about TENITE PLASTIC PIPE

NAME.....
TITLE.....
COMPANY.....
STREET.....
CITY.....STATE.....

HOW TO PROTECT VULNERABLE SURFACES AGAINST CORROSION

New TAPECOAT
Booklet Presents Proved
Methods of Protection with
Coal Tar Coating
in Handy Tape Form



Where to Use

TAPECOAT

The Coal Tar Protective Coating
in Handy Tape Form

In Performance
Record Since 1941
Proves TAPECOAT
the Answer to
Corrosion Problems

THE TAPECOAT COMPANY • EVANSTON, ILLINOIS

Wherever you have a corrosion problem, you will find this guide helpful in working out an economical and practical solution.

Based on the experience and research of TAPECOAT engineers since 1941, this factual booklet shows where and how TAPECOAT coal tar coating in handy tape form can be used to overcome corrosive action—both underground and above ground. It presents proved methods of protecting pipe, pipe joints, fittings, couplings, tanks and other vulnerable surfaces, together with case histories demonstrating the ability of TAPECOAT to meet the most severe conditions.

Write for your copy
of this helpful
guide today.

The **TAPECOAT** Company
Originators of Coal Tar Tape Protection

1521 Lyons Street
Evanston, Illinois

Two Discussions to Be Held March 19



Pogacar



Callahan

The General Corrosion Problems Round Table and the Pipe Line and Underground Corrosion Symposium will be held Thursday, March 19. The general problems discussion, of which C. F. Pogacar of Atlantic Refining Co., Philadelphia, and L. E. Stout of Washington University, St. Louis, are chairmen, will be held from 9 to 11:30 a.m. The pipe line and underground discussion will be held from 2 to 4:30 p.m. M. C. Callahan of Gulf Refining Company, Tulsa, is chairman of the pipe line session. Both sessions are part of the Chicago Conference technical program.

Questions have been solicited from the NACE membership, by Mr. Pogacar for the general corrosion round table. Questions from the floor are solicited also, and if past experience is an indication, both sessions will be well-attended and the discussions will develop useful information.

Tulsa Short Course Is Scheduled March 4-6

The Fourth Annual Tulsa Section NACE Short Course for Pipeliners is scheduled for March 4-6, according to W. A. Hutchison, Chief Corrosion Engineer, Sinclair Pipe Line Company, chairman of the committee on arrangements. The course is designed specially for foremen, superintendents, field engineers and inspectors.

The school's topic "Practical Control of Pipe Line Corrosion" will be covered by group discussions, lectures and field demonstrations led by practical authorities such as Fred M. Cloninger, Texas Pipe Line Co.; Lancy F. Heverly, Great Lakes Pipe Line Co.; F. M. Hieronymus, Barrett Div. of Allied Chemical & Dye Corp.; Marshall E. Parker, Jr., Cormit Engineering Co. and Y. W. Titterington, Pipe Line Anode Corp.

The committee on arrangements, besides Mr. Hutchison, includes Edward A. Bartolina, Moorlane Co.; James C. Bell, Service Pipe Line Co.; Hugh A. Brady, Pipe Line Anode Corp.; Melvin E. Maddox, Pittsburgh Coke & Chemical Corp. and T. D. Williamson, Jr., T. D. Williamson, Inc.

The \$10 registration fee covers a buffet supper and transportation by chartered buses to the demonstration site near Tulsa. Mayo Hotel will be headquarters and room reservations may be made individually. Registration forms may be obtained from Hugh A. Brady, Box 996, Tulsa, Okla.

Standardization Urged For Atlantic Nations

Standardization of products by the North Atlantic Treaty Alliance nations is an urgent must according to William L. Batt, formerly president for 27 years of SKF Industries, and more recently, U. S. minister for economic affairs to the United Kingdom.

Lack of standardization is strangling production in NATO countries and especially in the U. S., Great Britain and Canada, Mr. Batt said. He made an ominous comparison with the Russian policy of complete standardization both within her own borders and in all satellite countries.

Much of the serious production difficulties the world faces could be remedied by standardizing practices in making specifications, engineering drawings and blue prints, according to Mr. Batt. He pleaded with top American management men in the three English speaking countries to direct their engineers to establish the needed standards. He called standardization of drawings and blueprints probably the most important single step the three countries could take to make better use of their combined resources. "What is lacking is simply the desire to coordinate, a lack of understanding of the significance and importance of international negotiation of the problem," he said.

Mr. Batt, vice-chairman of the War Production Board during World War II, spoke to American Standards Association at New York, November 25. "This is the third time we have come to the aid of Europe, and each time we have faced the same headaches, the same delay and waste arising from lack of adequate national and international standards. At some of the meetings I have attended in the past year I could have closed my eyes and told myself, 'This is 1942 all over again'."

To illustrate how lack of standardization can imperil the common security of NATO countries, Mr. Batt told of joint maneuvers by American and French units that became snarled because American artillerymen used French maps which were marked in degrees and kilometers to aim U. S. guns calibrated in miles and yards.

By contrast, the Soviet Union is pushing all its seven European satellites to standardize their weapons and industrial production with hers. New engineering standards received from Czechoslovakia now carry the same number as the Russian standard, are printed in both Russian and Czech, and carry notations on their differences.

In Mr. Batt's opinion, it is only through increased production accompanied by expanded foreign trade can Western Europe rearm, maintain its standard of living, and eventually free itself from dependence on U. S. aid. While it is impossible to accurately tell the results of American technical and material aid to Europe, there are definite and encouraging increases in output per worker.

The NACE Committee on Education welcomes inquiries concerning the holding of cooperative short courses on corrosion. The association can frequently help with advice and otherwise educational institutions interested in holding such courses.

AMERICAN CHEMICAL PAINT COMPANY

AMBLER  PENNA.

Technical Service Data Sheet

Subject: PROTECTING ALUMINUM WITH **ALODINE®**

"ALODINE" No. 100

"Alodine" No. 100 forms an amorphous phosphate surface on aluminum which is thin, tough, durable, non-metallic, continuous with and a part of the basis metal. The "Alodine" film anchors paint, prolongs paint life, and protects aluminum exposed unpainted to the atmosphere.

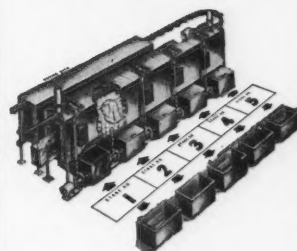
With the "Alodine" No. 100 bath at its normal temperature of 120° F., coating time by immersion approximates 1½ minutes—and by spraying, 15 to 20 seconds. Coating times and bath temperatures can be varied to suit operating conditions.

"ALODINE" No. 600

"Alodine" No. 600 forms corrosion-resistant coatings that provide excellent protection for unpainted aluminum and also make an effective paint-base. This grade is recommended for use in place of "Alodine" No. 100 on aluminum parts that are to remain unpainted or to be only partly painted; and on all aluminum castings and forgings whether or not these are given a paint finish.

"ALODINE" FLOW SHEETS

MULTI-STAGE POWER WASHER FOR SPRAY ALODIZING



IMMERSION TANKS FOR DIP ALODIZING

PROCESS SEQUENCE

1. Clean
2. Rinse
3. "Alodine"
4. Rinse
5. Final Rinse

NOTE: Equipment can be of mild steel throughout, except the "Alodine" stage which must be of acid-resistant material.

"Alodine" No. 600 is applied at room temperature (70° to 120° F.). Recommended coating times are 3 to 5 minutes for an immersion process and 1 to 1½ minutes for a spray process.

COATING DATA	"ALODINE" NO. 100	"ALODINE" NO. 600
COMPOSITION	Amorphous phosphate.	Amorphous mixture of metal oxides and chromates.
COLOR	Depending on alloy treated, color range is from an iridescent blue-green to a dark slate gray.	Depending on time of treatment, color range is from golden iridescent to light brown.
THICKNESS	From 0.01 to 0.08 mil. No appreciable dimensional changes occur when aluminum is Alodized.	From 0.005 to 0.01 mil. No appreciable dimensional changes occur when aluminum is Alodized.
WEIGHT	30 to 300 mgs. per square foot. Optimum: 100 to 200 mgs. per square foot.	35 to 50 mgs. per square foot.
SOLUBILITY	Insoluble in water, alcohol, solvents, etc. Insoluble in most dilute acids and alkalis. However, strong acids and alkalis which attack aluminum may penetrate the "Alodine" film and react with the underlying metal. Slightly soluble in concentrated nitric acid. Soluble in molten sodium nitrate, etc.	Insoluble in alcohol, water, solvents, etc. Soluble in strong alkalis and acids.
ELECTRICAL PROPERTIES	High dielectrical resistance.	This coating is electrically conductive. Aluminum coated with "Alodine" No. 600 can be shielded—arc welded or spot welded.
HEAT STABILITY	Unimpaired at temperatures that melt aluminum.	Unimpaired at temperatures that melt aluminum.
FLEXIBILITY	Integral with and as flexible as the aluminum itself. Can withstand moderate draws.	Integral with and as flexible as the aluminum itself. Can withstand moderate draws.
ABRASION RESISTANCE	Approximately 90% of that provided by chromic acid anodized aluminum.	Approximately 90% of that provided by chromic acid anodized aluminum.
CORROSION RESISTANCE	Painted—superior to chromic acid anodizing. Unpainted—comparable with chromic acid anodizing. Meets MIL-C-5541 and other Government Finish Specifications.	Exceeds requirements of MIL-C-5541 and even AM-QQ-A-696a (anodic films).
PAINT-BONDING	Excellent. Equal to or superior to anodizing. Meets MIL-C-5541 and other Government Finish Specifications.	Excellent. Meets MIL-C-5541 and other Government Finish Specifications.
TOXICITY	Non-toxic.	Non-toxic.
BIMETALLIC CORROSION RESISTANCE	Shows good resistance against bimetallic or galvanic corrosion.	Shows good resistance against bimetallic or galvanic corrosion.



WRITE FOR FURTHER INFORMATION ON "ALODINE" AND
ON YOUR OWN ALUMINUM PROTECTION PROBLEMS.



Two Sessions Set for Chemical Industry Papers

Nine papers will be presented at two sessions of the Chemical Industry Symposium at the Chicago NACE Conference. Four papers are scheduled to be given at the 2 to 4:30 p.m. session on Thursday, March 19, and five papers on the following morning from 9 to 11:30 a.m., Friday, March 20. Chairmen of this symposium are C. A. Coberly of Mallinckrodt Chemical Works, St. Louis; E. G. Holmberg, Alloy Steel Products Co., Linden, N. J., and G. F. Lockeman, Procter & Gamble Co., Cincinnati.

The first session will deal with metals and plastics while the second includes two papers on the corrosion of aluminum, one on data correlation, one on acids corrosion and a study on the resistance of beryllium copper.

Abstracts of papers and biographies of authors are published below.

The Behavior of Titanium in Sulfuric and Hydrochloric Acids

By Warren W. Harple, Allegheny Ludlum Steel Corp., Pittsburgh

Warren W. Harple, a graduate of Rensselaer Polytechnic Institute, Troy, N. Y., holds a BS degree in chemistry, 1951. Since graduation he has been employed by Allegheny Ludlum Steel Corp. as research chemist. He is a member of Sigma Xi, NACE and is co-author of three recent papers on metallurgy.

Abstract

Titanium, like the stainless steels and many other common metals, exists in both an active and a passive state and its corrosion resistance in a particular medium depends upon whether or not the metal is able to maintain its passivity. This paper gives corrosion rates for titanium in sulfuric acid from 0-95 percent and in hydrochloric acid from 0-37 percent at four different temperatures and shows the active-passive boundary for these acids.



Harple

Data are also given showing how the addition of various inorganic salts and oxidizing agents affects the active-passive nature of titanium. Of particular significance is the inhibiting effect of various salts on the corrosion rate in hydrochloric acid. It is unusual to attain a high degree of inhibition of hydrochloric acid solutions and the behavior of titanium differs from most other metals in this respect.

Effects of Structures and Phases of Corrosion of Steel

By Fred A. Prange, Phillips Petroleum Company, Bartlesville, Oklahoma

Abstract

While the structure of carbon steel does not have a pronounced effect on such large scale corrosion processes as rusting, it does affect its performance in specific environments. Carbon in the pearlitic form may increase the corrosion resistance of plain carbon steels in fluids from high carbon dioxide oil wells, in furfural and in phenol. Sulfur, phosphorus, nitrogen and oxygen affect the attack in still other environments. Blis-



Holmberg



Coberly

tering is greatly influenced by inclusions and voids.

Corrosion resistant welds in pipe and pressure vessels are dependent on the process used, which in turn is reflected in the metallographic characteristics of the metal.

Phases of structure alter the corrosion resistance of chromium and chromium nickel steels. Carbides, inclusions and sigma phase have particularly pronounced effects in severe environments such as nitric acid. Certain temperature ranges are to be avoided when these steels are heat treated.

Various methods of alleviating the effect of carbide precipitation in austenitic steels are applicable but secondary effects must also be considered.



Prange

Corrosion Study in a Salt Plant

By H. O. Teeple, Corrosion Engineering Section, Development and Research Division, The International Nickel Company, New York City, and A. J. Abbott, Supervisor, Process and Development Division, Michigan Chemical Corp., St. Louis, Michigan

H. O. Teeple was graduated from the University of Michigan in 1937 (BSChE) and in July of that year became associated with the Westvaco Chemical Division of Food Machinery and Chemical Corp. In 1944 he joined the Corrosion Engineering Section, Development and Research Division of The International Nickel Co., Inc. Mr. Teeple is a member of American Chemical Society, Electrochemical Society, National Association of Corrosion Engineers, Technical Association of the Pulp and Paper Industry and the Canadian Pulp and Paper Association.

A. J. Abbott studied chemical engineering at Queen's University, Kingston, Ont., got his B.Sc. in 1938 and spent a further year on his M.Sc. In 1939 he joined Simonds (Canada) Abrasive Co., Arvida, Que., as control chemist and development engineer. He left this company in 1941 to go with Shawinigan Chemicals Ltd., Shawinigan Falls, Que., where he became a group leader in the Plant Research Department, engaged in process development and improvement. In March 1948 he joined Michigan Chemical Corp., St. Louis, Mich., as supervisor of the Development Department and about a year later the process engineering group and the quality control laboratory were placed under his supervision also. In October 1950, Abbott became engaged in chemical warfare work as Head of the Chemical Pilot Plant, Defense Research Chemical Laboratories, Dept. of National Defense, Ottawa, Canada. In Sept. 1951, he returned to Michigan Chemical as supervisor of the Process and Development Dept. Abbott is author of the article on calcium carbide and co-author of the article on fused alumina abra-

sives in the new Kirk-Othmer "Encyclopedia of Chemical Technology," has been awarded several patents, and is an abstractor for Chemical Abstracts. He is a member of the NACE, the AIChE and the ACS.

Abstract

Recently a modern salt evaporator was installed to produce sodium chloride from a natural brine in Michigan. The opportunity was presented to make a complete corrosion survey of the salt evaporator. Hence, field corrosion tests were made throughout the system. The results of these tests are present as well as other results illustrating the behavior of metals and alloys exposed to salt solutions.



Teeple

A discussion of the service performance of the materials of construction of the evaporator is also presented.

A flow sheet is shown wherein the test locations are indicated, the corrosion data are tabulated and correlated and photographs pertinent to the subject are shown.

The Use of All-Plastic Equipment and Piping in Technical Corrosion Protection

By J. L. Huscher, American Agile Corp., Bedford, Ohio

Joseph L. Huscher has been with American Agile Corporation since 1941, working originally on the development of special metallic welding electrodes and procedures. During two years in the Armed Forces was assigned to Chemical Warfare Service, doing research work on classified projects. Upon return from service he rejoined the American Agile Corporation to evaluate various plastic materials with regard to their corrosion resistance and the development of such plastic structural materials and their methods of fabrication. He holds a degree of BS in chemistry from University of Caen (France) and a BS in chemical engineering from Penn College (Cleveland).

Abstract

A new group of "construction"—materials—materials which can be used in form of fully fabricated processing equipment and unsupported pipe are now available to the corrosion engineer. These materials—plastics—are sometimes foreign to the corrosion engineer and in particular the concept of plastics as self-supporting structural material for anti-corrosive applications requires a greater familiarity with them technically as well as economically.

While hardly a plant in the chemical and allied field does not use plastics as coatings, adhesives, linings, gaskets, etc., the use of corrosion-resistant all-plastic piping and tubing and of all-plastic chemical processing equipment is a recent development which is finding



Huscher

(Continued on Page 43)

Two Sessions Set—

(Continued From Page 42)

rapid acceptance in the field of technical corrosion protection.

The chemical and physical properties of the most important plastic materials which can be considered for these uses are reviewed and compared with the more common corrosion-resistant materials. The technological and also economical aspects of this group of "construction" materials are discussed with particular attention to applications where such all-plastic fabrications or piping will outperform as well as substitute for previously used materials.

The constant growth of the chemical industry increases the problems of corrosion and through discriminate and proper applications of plastics—some of which are shown in illustrations—these plastics are becoming extremely valuable tools in the constant fight against corrosion.

Resistance Of Aluminum Alloys To Weathering

By C. J. Walton, J. A. Nock, Jr. and D. O. Sprowls, Aluminum Company of America, New Kensington, Pennsylvania



Walton

C. J. Walton, assistant chief of the Chemical Metallurgy Division, Aluminum Research Laboratories of Aluminum Company of America, joined Alcoa in 1931 and was promoted to his present position in 1946. His entire service with Alcoa has been associated with the evaluation of resistance to corrosion and stress corrosion cracking of aluminum alloys, particularly in natural environments. He obtained a degree in metallurgical engineering from Carnegie Institute of Technology Evening School (1942). He has contributed to several technical papers and is a member of NACE and The American Society for Metals.



Nock

J. A. Nock, Jr. graduated from Pennsylvania State College in 1923 with a BS degree in Electrochemical Engineering. Since then he has been employed by Aluminum Company of America in research work, particularly with the development of wrought alloys presently in use. His work has also included the development of fabricating practices and thermal treatments for aluminum alloys and has presented a number of technical papers covering these subjects. A number of patents have been granted to him. His present position is Assistant Chief of Physical Metallurgy Division of Aluminum Research Laboratories.



Sprowls

D. O. Sprowls, Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Company of America. He has been with the Aluminum Research Laboratories since 1936 except for five years attending Drexel Institute of Technology, where he obtained a BS in chemical engineering. His work has been

associated with the evaluation of the resistance to corrosion and stress corrosion cracking of aluminum alloys, particularly in natural environments. He is a member of NACE.

Abstract

Extensive data selected from tests of many thousands of specimens of aluminum alloys, exposed in various natural atmospheres for periods as long as 20 years, are presented graphically. These data provide comprehensive coverage of the resistance to weathering of outstanding types of wrought and cast aluminum alloys, with particular emphasis being given to those alloys used in architectural and structural applications. The effects of weathering were evaluated by measurement of change in strength and depth of attack of specimens exposed for periods up to 20 years in natural atmospheres and for as long as 52 years in actual service.

Aluminum alloys have been evaluated in a sufficient number of different types of atmospheres at widely separated geographic locations to predict with reasonable assurance the performance expected under most conditions normally encountered. The corrosion of aluminum alloys, both wrought and cast, exhibits a "self stopping" characteristic; that is, the rate of attack after an initial exposure period of about one to two years decreases to a very low value, generally to less than 0.2 mil per year. The aluminum alloys displayed high resistance to corrosion and although some differences were noted, these differences often were subordinate to other characteristics of interest, such as strength, formability, appearance and cost.

Resistance Of Aluminum Alloys To Chemically Contaminated Atmospheres

By W. W. Binger, R. H. Wagner and R. H. Brown, Aluminum Company of America, New Kensington, Pennsylvania



Binger

W. W. Binger has been with the Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Company of America since 1943. He has been concerned chiefly with the development of applications of aluminum alloys in the chemical industries. During 1944 and 1945 while on leave from Alcoa he was associated with the Manhattan Project at both the University of Chicago and Oak Ridge, Tennessee. He was graduated from the University of Wisconsin in 1943 with a BS in Chemical Engineering.



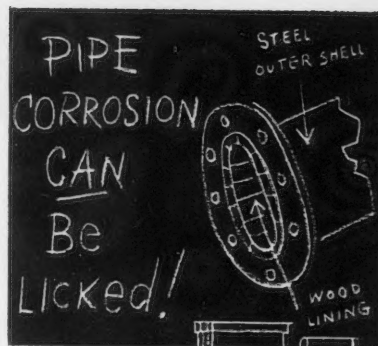
Brown



Wagner

R. H. Wagner has been with the Chemical Metallurgy Division of the Aluminum Research Laboratories, Aluminum Company of

(Continued on Page 44)

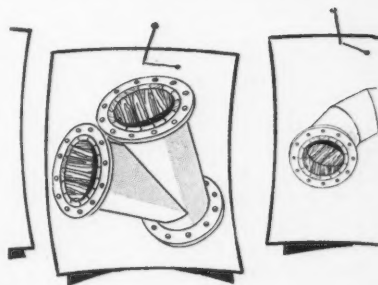


and it's as
easy as **MPC!**

MPC Wood-Lined Steel Pipe is the efficient and economical answer wherever corrosion, abrasion, frictional resistance or sliming is a problem.

Ideal for corrosive liquids, gases and fumes including aggressive waters, industrial waste liquors, pulps, slurries, acid, alkali and salt solutions.

For service up to 180° F. and 250 p.s.i. Higher pressure ratings for special service requirements. All pipe flanged and available in 10' and 20' standard lengths or "tailor-made" to your specifications. Easy to cut and reflare. All flanges have standard ASME bolt circle.



Woodlined fittings are available in standard and special designs for all diameters. For catalog and additional information write Dept. C.



MICHIGAN PIPE COMPANY

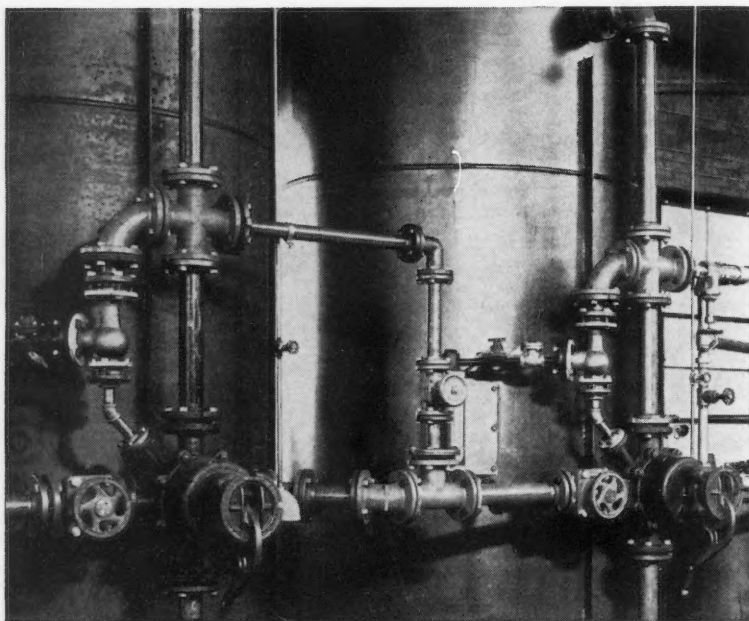
Bay City • Michigan

Manufacturers of Wood-Steel, Saran Rubber-Lined, Stainless Steel and Monel Piping. Represented nationally by Saran Lined Pipe Co. Detroit, (Ferndale) Michigan.

DOW

CUT CORROSION COSTS

install corrosion-resistant
SARAN LINED STEEL PIPE
for long, trouble-free service



Saran Lined Pipe, Fittings and Valves are used in this automatic water deionizer in a large water purification system. Installations such as this give trouble-free service for many years.

Saran Lined Pipe Company
2415 Burdette Ave., Ferndale, Mich.

Please send me a copy of your catalog on
Saran Lined Pipe, Valves and Fittings.

Name _____

Title _____

Company _____

Address _____

City _____ State _____

Corrosion-resistant Saran Lined Steel Pipe sharply reduces repair and maintenance costs in corrosive piping installations. Downtime is cut to a minimum because this rigid pipe has high pressure strength and durability—which mean dependable, long-term service. Easily installed Saran Lined Steel Pipe can be cut and threaded in the field—no need for special tools or handling. Wherever superior resistance to most chemicals and solvents is demanded, be sure to consider Saran Lined Pipe, Fittings and Valves. Write to the distributor: SARAN LINED PIPE COMPANY, 2415 Burdette Avenue, Ferndale, Michigan. Offices in: New York • Boston • Pittsburgh • Tulsa • Philadelphia • Chicago • Portland • Indianapolis • San Francisco • Houston • Denver • Los Angeles • Seattle • Cleveland • Charleston, S. C. • Toronto • Montreal. Clip and send today!

you can depend on **DOW PLASTICS**

DOW

Two Sessions Set—

(Continued From Page 43)

America since 1946. Mr. Wagner worked successively in the aircraft engine and electroplating fields before becoming associated with the Aluminum Research Laboratories. A native of Pennsylvania, he received a BS degree in Chemical Engineering from the University of Pittsburgh, Pittsburgh, Pennsylvania in 1942.

R. H. Brown, Chief, Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa. He has been engaged in corrosion work for 23 years, 21 of which were with Aluminum Research Laboratories and two as research associate in corrosion engineering, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology. He has a BS in chemical engineering from Drexel Institute of Technology and a MS in chemical engineering from MIT. He is author of many technical papers on corrosion and is a member of several technical societies, being a member of NACE since 1945. He received the Whitney Award in 1950 and is Light Metals Correspondent for Corrosion.

Abstract

The excellent resistance of aluminum alloys to atmospheric weathering is well known and has been used to advantage for many years in architectural applications and general metal work. Because of this characteristic, considerable interest has been shown in aluminum alloys for plants and industrial buildings where the atmosphere is contaminated by fumes and chemicals that promote the corrosion of many metals and alloys.

Of the many factors connected with atmospheric corrosion problems in chemical plants, refineries and other industries those encountered most often are combinations of hydrogen sulfide, carbon dioxide, sulfur dioxide, hydrogen chloride, moisture and dirt. In general, it has been found that aluminum alloys are resistant to atmospheres containing these contaminants. In addition, the problem in most plants is further aggravated by the formation of dust and/or fumes. An active laboratory as well as field testing program is continuing to demonstrate that aluminum alloys of the type used for architectural applications are very resistant to corrosion by a wide variety of organic and inorganic chemicals.

The use of aluminum-base alloys in the coke, soda ash, sulfur, power, paper, salt, petroleum and petrochemical industries has reduced corrosion losses with resultant savings in maintenance costs. Some of the applications where aluminum alloys have proved successful are tank roofs, siding, roofing, windows, duct work, ladders, hand rails, instrument tubing and tread plate.

Corrosion By Acids At High Temperatures

By R. F. Miller, R. S. Treseder and A. Wachter, Shell Development Company, Emeryville, California



Miller

Abstract

A test method is described for obtaining
(Continued on Page 45)

Two Sessions Set—

(Continued From Page 44)

corrosion data with acids and other corrosives at temperatures above their normal boiling points. The method which has features of simplicity and general usefulness involves use of a flame-sealed heavy-wall glass tube as container for the metal specimen and corrosive fluid. The atmosphere over the fluid can be controlled and, by evacuating the tube before sealing, can be made to consist only of the equilibrium vapor at test temperature. It is estimated that the tubes withstand gas pressures up to about 1000 psig which corresponds to a test temperature of 285° C for water. Appropriate test safeguards are described.

Corrosion data obtained by this method are presented for various alloys exposed to sulfuric acid, phosphoric acid, nitric acid, formic acid, boric acid and phenol at different temperatures and concentrations.

Graphical Multiple Correlation Of Corrosion Data

By O. B. Ellis, Armo Steel Corporation, Middletown, Ohio

O. B. Ellis, Senior Research Engineer, Armo Steel Corp., received a BS in chemistry in 1922, an MS in physics in 1924 from the University of Louisville, Ky. After employment at Armo's Ashland, Ky. plant in 1929 he transferred to the company's research laboratories in 1932 where he supervises corrosion research activities.

Abstract

The evaluation of corrosion data by statistical methods often is desirable in order to obtain the maximum useful information from the data. This discussion is concerned with a graphical method for a multiple correlation analysis involving several variables. The graphical procedure is easier to use than mathematical procedures. Also, it permits visual evidence of the relationship between variables as the work progresses. The method is not

limited to simple linear functions.

For purpose of illustration, weight loss data from an atmospheric exposure of low alloy steels are studied. The method is described step by step and the effect of concentration of nickel, manganese, phosphorus and silicon on weight loss is shown. The final results of the graphical analysis are compared with a mathematical analysis of the same data.

Godard Will Head Symposium in 1954

H. P. Godard of Aluminium Laboratories, Ltd., Kingston, Ontario will be chairman of the 1954 Corrosion Principles Symposium to be given at the Tenth Annual Conference and Exhibition to be held at Kansas City in March 1954.

The Corrosion Resistance Of Beryllium Copper Surveyed

By J. T. Richards, Development Engineer, The Beryllium Corporation, Reading, Pa.

John T. Richards, Development Engineer of The Beryllium Corporation, Reading, Pa., served in the Navy in World War II as an engineering officer aboard a destroyer escort after having graduated from Cornell University in 1943 with a BS in mechanical engineering. He is a member of ASM, ASME, ASTM, AIME, SAE and British Institute of Metals.

Abstract

Available data is presented on the resistance offered by beryllium copper to corrosion by various media including fresh and salt water, acids, alkalies and liquid metals. Attack by several atmospheres is considered and the corrosion products as well as subscale formation are discussed. Corrosion fatigue and the influence of static stress on corrosion rates are also noted. Other forms covered include galvanic corrosion, cavitation erosion and selective attack. The effect of corrosion on the processing of beryllium copper products is presented, while typical applications where corrosion may present a problem are briefly reviewed.

Inquiries concerning advertising in Corrosion should be addressed to Central Office NACE, 1061 M & M Building, Houston 2, Texas.



Richards

F. L. Whitney to Head Kansas City Technical Program Committee

F. L. Whitney, Jr., Monsanto Chemical Co., St. Louis, technical program co-chairman for the 1953 Conference at Chicago will be technical program chairman for the 1954 conference at Kansas City. Mr. Whitney, long active in NACE affairs, will be receptive to suggestions concerning the program at Kansas City and will receive offers for presentation of technical papers.



Whitney

Metals Show Scheduled

Preparations are under way for the eighth Western Metal Exposition to be held at the Statler Hotel, Los Angeles, March 23-27. The exposition is in conjunction with the meeting of the Western Metal Congress and is sponsored by American Society for Metals and other technical groups. William H. Eisenman, national secretary, American Society for Metals, states the exhibit of metal production, fabrication and application will be given on a scale larger than any of the previous seven presentations in the West.



Ellis



*Announcement
of Special Interest to Constructors, Engineers
and Purchasers of Process Piping Equipment*

Ray Miller

Now Carries a Complete Stock of

**STAINLESS
WELDING FITTINGS**

Types 304, 304 ELC, 316, 347, etc. Schedules 5-10-40-80 and O.D. Sizes.
INCLUDING:

MONEL, NICKEL, ALUMINUM, INCONEL, EVERDUR, CARBON MOLY, CHROME MOLY

Immediate Delivery

RAY MILLER

Specialists in Resistant Materials
for Special Piping Problems

NEWARK, N. J. • HOUSTON, TEXAS • SO. CHARLESTON, WEST VIRGINIA

Coatings Symposium Covers Diverse Material

The Protective Coatings Symposium is expected to attract the usual interest presentations on this subject drawn at NACE Conferences. The session, to be held from 9 a.m. to 12 noon on Friday, March 20, has two association members from California as its chairmen. They are L. L. Whiteneck of the Board of Harbor Commissioners, Long Beach and N. K. Senatoroff of Southern Counties Gas Co. of California, Los Angeles.

The five papers scheduled include one on coating problems at atomic energy installations, a subject of wide interest currently; a report on field tests of a coating on a pipe conveying hot oil, a discussion of filiform corrosion, an analysis of the effects of steel composition on organic coatings and a report on the effect of weld seam and weld flux effects on coatings.

Abstracts of papers and biographies follow.

Coatings Research And Coatings Applications in Atomic Energy Installations

By Clyde D. Watson, Oak Ridge National Lab., P. O. Box P, Oak Ridge, Tennessee

C. D. Watson has been a member of the Chemical Technology Division at Oak Ridge National Laboratory for seven years and is now a Group Leader in charge of the Radiation Engineering Group in the Unit Operations Section. He was graduated from the University of Tennessee in 1943, with a BS degree in Chemical Engineering. Prior to employment at Oak Ridge National Laboratory, Mr. Watson served as navigator in the 14th Air Force in the European Theater of Operations.

Abstract

Surface protection problems unique to atomic energy installations have prompted a research program at Oak Ridge National Laboratory to evaluate protective coating systems and plastics in the presence of radioactivity. The findings have been broadly interpreted to indicate to the coatings industry criteria for coatings useful in radiochemical environments.

Protective coatings, (vinyl chlorides, especially) and polyethylene plastic, in comparison tests with stainless steel, lead, glass, transite, and concrete, were shown to be less susceptible to radioactive contamination and to be decontaminated more easily. Lack of fundamental data prevents adequate explanation of the superiority of one coating or plastic over another.

Coatings exposed to gamma radiation undergo physical deterioration, consisting of blistering and softening followed by drastic embrittlement and checking at a gamma exposure of 10⁶r. Halogen-bearing coatings and plastics released the halogen and, in the presence of moisture, produced the corresponding halide acid with attendant corrosion. Light-colored materials became discolored.

Coatings and plastics are definitely useful in protecting surfaces, with the possible exception of floors, in radiochemical laboratories and processing plants, most of which never handle the quantities of materials necessary to pro-



Senatoroff



Whiteneck

duce a 10⁶r exposure. They are of considerably less value in processing plants handling the products from a nuclear reactor, where the contaminants are present in multicurie amounts.

Generally from the coatings industry are needed the following:

1. Standard tests for comparing the contamination and decontamination properties of protective systems.
2. Materials resistant to radiation damage and decontaminable with water.
3. Protective surfaces that indicate by a color change the presence and approximate intensity of radiation.
4. Coatings carrying no charge in order that collection of radioactive particles may be prevented.
5. Continuous protective flooring, (no open fabrication joints), material.

Field Tests Of Exterior Coatings For A Pipe Line Conveying Fuel Oil Heated To 200° F

By E. R. Stauffacher, Southern California Edison Co., Los Angeles, and R. R. Davidson, Bechtel Corp., Wilmington, Cal.

E. R. Stauffacher was graduated from the Alabama Polytechnic Institute (Auburn) in 1910—BS in EE, (professional EE in 1920). In 1910 he became affiliated with the Southern

California Edison Company in Los Angeles. His work has been concerned with overhead and underground distribution systems, with power engineering involving the use of electricity on consumers' premises and with protection engineering covering the application of protective relays, lightning arresters and grounding systems to generating plants and substations. In 1927 he served as exchange engineer at the General Electric Company in Schenectady, N. Y., and during World War II he spent a short period at the California Institute of Technology on studies of wave action in Long Beach (Calif.) Harbor. His present work is concerned with corrosion control and the application of protective coatings throughout the system of the Southern California Edison Company.

Robert R. Davidson, is Plant Engineer in the Somatic Division of Bechtel Corporation, where he has been concerned with control and development of product quality since 1948. In prior years his activities as a design engineer resulted in varied but brief encounters with corrosion work dating back to 1936. During the war years he held supervisory positions in the Plant Engineering and Customer Service division of Lockheed Aircraft, and is a Registered Mechanical Engineer, State of California.

Abstract

Field experiments were made to determine a suitable exterior protective coating for an oil transmission pipe line to handle oil heated to 200° F. The pipe line, 41 miles in length, 8-inch Schedule No. 30 pipe, operating at normal working pressure of 600 to 800 psi with three combined heating and pumping stations spaced at approximately 13.5 miles, was designed to transmit fuel oil from the oil refineries to a steam-electric generating station.

To test stability four different coatings were applied to 20-foot lengths of 8-inch ID pipes connected in series and

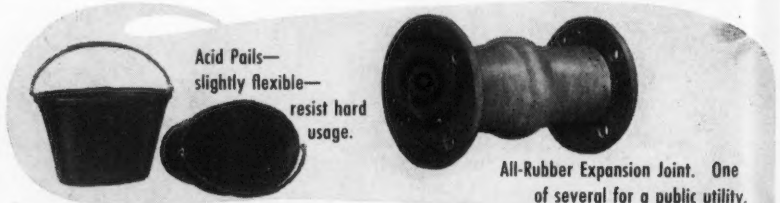


Davidson

(Continued on Page 47)



Watson



Acid Pails—
slightly flexible—
resist hard
usage.

All-Rubber Expansion Joint. One
of several for a public utility.

Just 2 of 10,000 ...

Yes—ten thousand applications of La Favorite Rubber Engineering know-how in a year. This "know-how" is something a customer cannot feel or see, but which, is nevertheless, an ingredient in every La Favorite product—time and use have demonstrated its value.

With a backlog of more than half a century of experience, and the third generation of rubber experts now actively participating, you may be sure any rubber use problem of yours, simple or complex, submitted to us will receive the benefit of these outstanding advantages.

Use La Favorite's rubber engineering know-how to your advantage. Send for report #363—send blueprints for estimates on your work.

LA FAVORITE RUBBER MFG. CO.

272 Wagaraw Road • Hawthorne, N. J.

RUBBER LININGS

RUBBER COVERING

RUBBER ENGINEERING

Coatings Symposium—

(Continued From Page 46)

buried in the soil. Oil heated to 200° F was then circulated through the pipe for approximately two weeks. Provision was made to apply an external pressure at three spots on each of the coatings of 10 psi, 50 psi and 80 psi by the use of suitable rods and weights. The depressions formed were measured carefully throughout the test to determine the rate and magnitude on each coating. Open sections of the ditch, approximately four feet in length for each coating, were provided to observe any sag which might take place on any of the coatings. After the experimental hot oil circulation was completed the ditch was opened and the coatings examined for distortion and adherence and electrical resistance measurements were made at the depression points.

Additional 40-foot pipe lengths with each of the four different coatings were then subjected to cold bending by standard field equipment to a total angle of 15° and a radius of approximately twenty pipe diameters (14 feet-5 inches). After each bend the coatings were examined for cracks and given a "holiday detector" test to supplement the visual examination.

Due to its ruggedness and freedom from distortion during the test the decision was made to recommend a ½ inch thick asphalt mastic coating, using a 250° F melting point asphalt for the hot oil pipe line exterior coating.

"Filiform Corrosion"

By M. Van Loo, Sherwin-Williams Company, Chicago.

Maurice Van Loo was born in Zeeland, Michigan, in 1901. He has attended Hope College, 1917-21, where he received an AB and MA (Honorary); University of Michigan, 1921-27, MS (1923). He was employed by Sherwin-Williams Company from 1927 to present in the following capacities: research chemist, Cleveland, Ohio, 1927-1933; Superintendent Chicago Technical Service 1933-1935; Assistant Director, Allied Research Laboratories, 1935-1942; Director of Paint Research from 1942 to present. He is author of papers in colloid and physical chemistry and paint technology and is a member of NACE, ACS, AIC (Fellow) AAAS, ASTM, FPVPC.

Abstract

Filiform corrosion is a thread-like type of corrosion which develops under protective coatings on certain metals, usually in humid atmospheres. It is characterized by directional growth and definite structure. Controlling factors

are the physical nature of the coating and the exposure conditions. Normally each growing thread consists of an active head of an unstable corrosion product and an inactive body of a stable corrosion product. Filiform corrosion usually appears in an apparently haphazard or disorderly pattern. However, its growth is uniform and orderly in direction,

rate and dimensions when developed under controlled conditions. The tracks

do not cross one another but deflect or join in a predictable manner.

To date no direct relationship has been found between filiform corrosion and the metallurgical pattern of the surface, the presence or absence of light, biological activity or the presence of inhibitive pigments. It has been observed under both non-metallic and metallic coatings, provided that the coatings are semi-permeable and are sufficiently elastic to yield without rupture to the volume of the oxide formed.

A theoretical explanation is offered for filiform corrosion, involving an initiating force, a driving force and a directing force. It is suggested that cor-

rosion anodes are initiated by an electrolytic mechanism as in ordinary corrosion. The driving force is the diffusion of the corrosive atmosphere into the active head, resulting in further metallic corrosion. The directing force is explained on the basis of concentration cells.

Illustrations include time-lapse motion photography in color.

Weld Seam and Weld Flux Effect on Metal Surface and Coating Life

By A. J. Liebman, Dravo Corporation, Pittsburgh, Pa.

A. J. Liebman is Assistant Director of Re-

(Continued on Page 48)



And, of course, our most sincere wish for you gentlemen who are battling with pipeline corrosion is that you outlive the Roskote with which you are protecting your pipelines today.

Roskote is a coating of indefinitely long life. It is made from resins chosen primarily for their exceptionally high electrical resistivity. It is a quick drying cold-applied mastic, characterized by its extreme toughness, high tensile strength, resistance to both temperature changes and reaction to either acid or alkaline soil conditions.

Roskote requires no primer; requires no field mixing or heating. You simply open the container and begin spraying or brushing. Ask for a free sample. Try it for fast, easy application. Subject it to the most severe test your pipeline is apt to meet and see for yourself! Write:

Ask about the
Roskote-Glas-Wrap
reinforced
protection for pipelines.

ROYSTON
LABORATORIES, INC.,
P. O. Box 112-C
BLAWNOX, PA.

MANUFACTURERS OF QUALITY INDUSTRIAL
COATINGS RESISTANT TO CORROSION
BY ACIDS, ALKALIES, ELECTROLYSIS,
HEAT, MOISTURE AND WEATHER.

VIEW ROYSTON PRODUCTS IN BOOTH 66 AT NACE



Van Loo

Coatings Symposium—

(Continued From Page 47)

search & Development for Dravo Corporation and its Subsidiaries, Pittsburgh, Pa. He is a member of National Association of Corrosion Engineers, serving as Chairman of TP-6G Surface Preparation Committee during the past three years. At present, he is Chairman-elect of the TP-6 Technical Practices Committee. Mr. Liebman is also a member of the American Society for Testing Materials, serving as Chairman of Committee on "Standards Covering Ferrous Surfaces for Painting," and a member of the Steel Structures Painting Council, serving on the Research Committee and also as Chairman of the Sub-Committee for Surface Preparation.

Abstract

Modern structural and equipment designs utilize the economical advantages of weldments. Examples are simple brackets as well as large items, such as motor and machine frames, ship's hulls and bridge structures to mention only a few.

A weldment offers greater rigidity than is experienced with most riveted or bolted joints. Due to the nature of the assembly, greater stresses develop in most welded joints than found in riveted or bolted joints. In most cases, weldments can be so designed that these stresses will not become harmful to the structure. In other cases, annealing is necessary to relieve



Liebman

these stresses.

When coatings are applied to welded sections and weld seams, these underlying changes in the metal have no apparent detrimental effect on the coating's adhesion if the surface of the weld seam has been prepared in accordance with the general good practice for other steel surfaces. The important difference between clean steel and average weld seams is found in the presence of interference products in the form of weld flux slag and weld flux fume dust deposits on the weld seam and to within several inches of it.

The peaks and valleys which are especially extreme on hand welding seams, will often cause harmful coating deposit variations. Disturbed mill scale will also reduce the ultimate performance life of a protective coating system. Weld flux slag is chemically highly alkaline and physically very brittle. Neither characteristic is desirable under any paint film. If the alkalinity of the slag can be held inactive, its brittle condition will soon cause a separation between metal and flux, thus taking with it the paint film and exposing the metal to the environments. In humid environments, the alkalinity of the flux causes action on the metal, inciting early rusting of the metal in direct contact with and directly adjacent to the slag. Rust creepage results from these early local attacks, ultimately causing complete destruction of large areas of paint several feet away from the original local cause of damage.

The presence of weld flux fume dust will accelerate the corrosivity of the slag, causing quick paint film separation at metal interface prior to the general corrosion attack.

The paper describes the use of primers,

mastics, wetting oils, chemical treatments, surface preparation and prewelding compounds and their effects on weld seam protection under various environments.

Effects of Composition of Steel on the Performance of Organic Coatings in Atmospheric Exposure

By F. L. LaQue, International Nickel Co., Inc., New York, and J. A. Boylan, Parker Rustproof Co., Detroit

James A. Boylan, a native of Detroit, Michigan, is employed by the Parker Rust Proof Company there. He started in the Testing Laboratory in 1929 and has spent most of the time since in the field of corrosion testing and surface treatment. He presently is in charge of the Technical Service Section of the Technical Division.

Abstract

The investigation described provides at least a partial answer to the question as to whether the improved atmospheric corrosion resistance of alloy steels is of any advantage when they are painted.

The steels represented a 20:1 difference in atmospheric corrosion between an exceptionally low copper content ingot iron and a typical low alloy high strength steel.

The paint system was a common automobile finish—a pigmented baking alkyd primer with pigmented baking urea modified alkyd top



Boylan

(Continued on Page 50)

MIDDLE WEST COATING & SUPPLY

COMPLETE CORROSION MITIGATION PRODUCT AND EQUIPMENT LINE

CORROSION
dinary
tectiv
surfac
for an
But B
are th
1. Un
mastic
specia
pitch
purpo
you k
posed

PIPE JOINT PROTECTION WITH TAPECOAT

RECTIFIERS
RICHARDSON-ALLEN CORP.

GRAPHITE ANODES & BACKFILL
NATIONAL CARBON CO.

FLANGE INSULATORS
NELSON ELECTRIC CO.

ELECTRONIC HOLIDAY DETECTOR
D. E. STEARNS CO.

MAGNESIUM ANODES
APEX SMELTING CO.
5 LB. - 10 LB. - 17 LB.
- 32 LB. - 50 LB.
BARE OR ANODE PAK

GRIP-TITE
PIPE LINE
ANCHOR
ASSEMBLY

PIPE LINE FELT
NICOLET INDUSTRIES
QUALITY FELT

TANK PAINT
KOPPERS NO. 50
WITH TOP
COAT NO. 28

INSULATING COUPLINGS

KOPPERS NO. 50

BITUMASTIC
PRIMERS

NICOLET ASBESTOS FELT CAN
BE MADE TO YOUR PARTICULAR
SPECIFICATIONS

INSTRUMENTS
NELSON ELECTRIC CO.

SHUNTS
AMERICAN STEEL & WIRE CO.

1. Un
mastic
specia
pitch
purpo
you k
posed

**VISIT US AT BOOTHS
100 AND 101,
NATIONAL CONVENTION,
SHERMAN HOTEL,
CHICAGO**

We Invite Your Immediate Inquiry . . . Call . . . Write . . . Wire

MIDDLE WEST COATING & SUPPLY

207-A Daniel Bldg.
P. O. Box 153

TULSA, OKLAHOMA

Telephone 2-5215
or 2-5216

You can't stop a rhino with a popgun



You can't stop corrosion with ordinary paints ... it takes **BITUMASTIC COATINGS!**

CORROSION can't be stopped by ordinary paints or conventional protective coatings. They can't protect surfaces against the ravages of rust for any appreciable length of time. But Bitumastic Coatings can. Here are three principal reasons:

1. Unlike maintenance paints, Bitumastic® Protective Coatings are specially formulated from a coal-tar pitch base* that is, for all practical purposes, impervious to water. When you keep moisture away from an exposed surface, you *stop* corrosion.

2. Bitumastic Coatings provide an extra-tough, extra-thick barrier against corrosive elements—a barrier that is impenetrable. These coatings provide up to 8 times the film thickness of conventional paint coatings.

3. Bitumastic Coatings stop corrosion caused by moisture—acid fumes

—alkaline fumes—corrosive soil—salt air—heat.

**Hi-Heat Gray contains a metallic base.*

There are 6 Koppers Coatings—formulated to control corrosion of metal and deterioration of concrete. Use the coupon for full information, or see our catalog in Sweet's Plant Engineering File.

SEND FOR SET OF FREE BOOKLETS!

Koppers Company, Inc., Tar Products Division
Dept. 204-T, Pittsburgh 19, Pa.

Please send me, without charge or obligation, complete information on corrosion prevention.

Name

Address

City Zone State



BITUMASTIC PROTECTIVE COATINGS

REG. U.S. PAT. OFF.

SOLD THROUGH
INDUSTRIAL
DISTRIBUTORS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 204-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

Educational Lectures Planned on Fundamentals

Lectures stressing the fundamental aspects of some corrosion phenomena will be given on three days during the NACE Chicago Conference. The Educational Lectures will be delivered by corrosion workers with many years of experience in theoretical and practical corrosion mitigation. All lectures will begin at 4:30 p.m. It is the intention of the lecturers to develop further the ideas and processes explained in the motion picture "Corrosion in Action" which will be shown four times during the week. Persons who wish to attend the lectures are asked to see the motion picture before attending the lectures. R. B. Hoxeng and R. C. West are chairmen of the program.

The schedule of lectures follows:

Fundamentals of Corrosion, by R. B. Hoxeng, United States Steel Corp., Pittsburgh, Tuesday, March 17, 4:30 p.m.

Factors Controlling the Amount and Distribution of Corrosion, by H. H. Uhlig, Massachusetts Institute of Technology, Cambridge, Wednesday, March 18, 4:30 p.m.

Use of Protective Coatings in Corrosion Control, by E. G. Bobalek, Case Institute of Technology, Cleveland, March 19, 4:30 p.m.

Abstracts of the authors follow.

Fundamentals of Corrosion

By R. B. Hoxeng, U. S. Steel Corp., Pittsburgh

Abstract

The electrochemical principles of corrosion illustrated in the INCO film "Corrosion in Action" will be applied in more detail to such subjects as galvanic corrosion, concentration cell corrosion, and cathodic protection. Certain aspects of localized corrosion attributable to the structure of the metal will be reviewed. Polarization and over-voltage will be explained on the basis of electrochemical reactions at the metal surface.

Factors Controlling the Amount and Distribution of Corrosion

By H. H. Uhlig, Massachusetts Institute of Technology, Dept. of Metallurgy, Cambridge

Abstract

This lecture will consider why some metals corrode uniformly, why others are pitted and why certain metals are highly corrosion resistant. How changing the environment can affect corrosion product films on the metal surface will be explained in terms of diffusion rates and solubility products. Polarization, passivity and inhibition will be discussed and related to changes with time of the corrosion rate and corrosion intensity.

Use of Protective Coatings for Controlling Corrosion

By E. G. Bobalek, Case Institute of Technology, Cleveland

Abstract

The functions of different types of barrier films will be reviewed. The different types of protective coatings will be classified with regard to their physical or chemical properties. Particular attention will be given to organic coatings and to the importance of permeability, adhesion and cohesion, composition and pigmentation. Anti-fouling and high-temperature coatings will be described together with the use of protective coatings in conjunction with cathodic protection.



Hoxeng



West



Uhlig



Bobalek

Inspection of Technical Papers Is Provided

According to the association's practice, copies of technical papers presented at the conference made available prior to delivery by authors, will be provided for inspection by press representatives. The association's regulations limit abstracts to one-third of the total paper before publication in the official journal "Corrosion."

NACE does not customarily make preprints of technical papers available, although some authors provide copies of their manuscripts prior to presentation.

The time and place at which these papers may be inspected will be published on the bulletin board.

Packing Techniques Discussed at Camden

The preserving and packing of metal parts, both military and civilian, for shipment and storage throughout the world was the subject scheduled for the November 24-25 meeting at Camden, N. J. of the Joint Industry Conference on Preservation-Packing.

Included on the agenda were: "Discussion of Various Types of Preservatives (Hot Dip, Solvent Cut-Back, Oil and Grease Types and of the Basic Materials Used in Compounding," Charles W. Griffiths, R. M. Hollingshead Corp.; "Correlation of Laboratory Tests with Field Experiences Covering Various Types of Corrosion Preventives," Gordon Mustin, Navy Dept.; "History and Theory of Polar Compounds and Demonstration," Robert C. Adams, U. S. Naval Laboratory, and Stanley W. Coryell, R. M. Hollingshead Corp.

Other papers and their authors were: "Discussion of Fingerprint Remove; Compounds, and Demonstration," Maj. L. E. Michael and Lt. O. R. Cunningham, U. S. Air Force; "General Interchange of Problems and Ideas on the Preservative Phases of Bearing Preservation and Packing," William Boston, Freedom-Valvoline Oil Co., and James DeGroot, Detroit Arsenal; "Discussion of Laboratory and Field Experiences with Corrosion and Its Prevention, Including Fingerprints, Staining, etc.," Ed. Bolen, Allison Div. General Motors Corp., J. H. Gustafsen, Marlin-Rockwell Corp., and W. D. McMaster, Research Laboratories Div., General Motors Corp.; "Discussion and Demonstration on New Cold Dip, Curing Type Plastic Compound," M. R. Gatto, R. M. Hollingshead Corp.; and "Use of Peelable

Plastics for Preservation of Small High Production Non-Military Parts," J. J. Gallagher, Diesel Equipment Div., General Motors Corp.

AICHE Sessions Held On Human Relations

Human Relations was the subject at a symposium held at the Cleveland, Ohio meeting of the American Institute of Chemical Engineers. Need of the individual engineer for an understanding of human factors has been emphasized by the movement of technically trained men into management posts where the principal job is the direction of people, it was brought out.

According to Professor Paul Pigors, Massachusetts Institute of Technology, "the aloofness of technical men to the problems of working management in dealings with people has inhibited the development of the engineer to executive status."

The Inter-Society Corrosion Committee was organized to help eliminate duplicated research into corrosion matters.

Coatings Symposium—

(Continued From Page 48)

coats, with and without zinc phosphate (Bonderite) pretreatment.

Test panels were exposed 80 feet and 800 feet from the ocean at Kure Beach, N. C., in an industrial atmosphere at Bayonne, N. J., and in a rural atmosphere at Morenci, Michigan.

The principal findings were:

1. The low alloy steel performed best, the copper steel next and the low copper content open hearth iron was worst whether painted or bare.
2. The zinc phosphate pretreatment improved the performance of all painted steels. This advantage increased with the severity of the atmosphere and with the vulnerability of the steels to attack.
3. The best performance was that of the low alloy high strength steel with a zinc phosphate pretreatment.
4. Exposure for a few weeks 80 feet from the ocean at Kure Beach led to the same conclusions as exposure for much longer periods elsewhere.
5. The marine atmosphere 800 feet from the ocean at Kure Beach was less damaging to bare steel, but more damaging to painted steel than the industrial atmosphere at Bayonne.

NEW PRODUCTS — Materials — Service — Literature

Rossaul No. 57, a phosphoric based material, will remove light oil films and which acts as a bond for the prime or color coat without penetration of the alumina oxide surface, the makers, the Rossaul Co., 170 Fifth Ave., New York, when air dried will create a phosphate coating on the surface of aluminum 10, N. Y. state.

Branson Instruments, Inc., Stamford, Conn. has released a six-page folder describing the theory and operation of the "Coatingage" Model 600. The portable instrument is used to measure the thickness of non-magnetic coatings on magnetic bases and to detect pin-holes in non-conductive coatings on conductive bases. One of the most important applications for the instrument, its maker says, has been in the examination of corrosion protective coatings for thickness and film continuity.

The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. has published "Heat Resistant and Corrosion Resistant Alloy Castings in Industry," 48 pages. The booklet describes typical compositions regularly produced along with their applications, limitations and the types of service for which they are suitable. Illustrations show applications of typical alloys by industry. Charts compare creep strength of various alloys, resistance to corrosion in certain media and to oxidation at elevated tem-

peratures. Tables of composition list principal Alloy Casting Institute designations as well as certain proprietary alloys.

The Babcock & Wilcox Co., Beaver Falls, Pa., has published a new data card of interest to engineers associated with the design, fabrication and application of equipment using stabilized stainless steel tubing. Known as bulletin TDC-144 it discusses B & W Croloy 18-8 Ti (AISI Type 321). Included are condensed data on corrosion resistance, creep strength, oxidation resistance, mechanical properties, machinability, welding characteristics, heat treatment and physical properties. The firm also announces the Cleveland district sales offices has moved into larger facilities. The headquarters are located on the fourteenth floor of the National City Bank Building, 629 Euclid Ave.

Glidden Company has purchased the plant of Eagle-Picher at Atlanta, Ga. and plans to double its capacity.

Agilene cast tubing, manufactured by the American Agile Corp., P. O. Box 168, Bedford, Ohio, a pure, unpigmented polyethylene, is now furnished in straight 20-foot lengths for easy installation. Sizes are from 1/4-inch to 30 inches inside diameter, with 1/4-inch through 1-inch sizes in coils, while larger tubing

is furnished in multiples of 4-foot sections joined by hot gas welding.

Klem Chemicals, Inc. 14401 Lanson, Dearborn, Mich. is producing a phosphoric acid cleaner in concentrated form for ferrous metals. Designated Rust-Sol No. 123, it can be applied either by brush-on or immersion methods and rinsed off with clear water. The material activates the surface with a slight etch and iron phosphate coating which makes a good paint base. Its fumes are non-corrosive and non-toxic, the company says.

Wilbur and Williams Co., 130 Lincoln St., Boston 35, Mass. has published a Quick Reference Index Maintenance Painting Guide in the form of a compact four page folder for maintenance superintendents and engineers. Concisely given are Maintenance Problems of Industry and the answer for them listed such as the painting of metal for rust control, painting without odor, protecting concrete floors and walls, protection against chemicals and corrosion. How to cut maintenance costs through the use of paint coatings designed for the purpose is clearly outlined.

Tygon Corrosion-Resistant Gasketing, a new bulletin G-520 has been issued by the U. S. Stoneware Company, Akron

(Continued on Page 53)

NICOLET INDUSTRIES, INC.

QUALITY MANUFACTURER OF

NICOLET ASBESTOS PIPE LINE FELT

Make

Nicolet Regular 15# Asbestos Pipe Line Felt.

Nicolet Perforated 15# Asbestos Pipe Line Felt.

Nicolet Medium Weight 8# Asbestos Pipe Line Felt.

Other weight felts which are available because Nicolet is a custom manufacturer of Felt Products.

Nicolet Asbestos Pipe Line Felt has the minimum organic content and application strength is obtained without the use of organic reinforcements, such as hair.

Write for your copy of the new Nicolet Catalog
ALL INQUIRIES WELCOME

VISIT US AT *BOOTHS 100 AND 101, NATIONAL CONVENTION, SHERMAN HOTEL, CHICAGO



The Felt With a Future

MANUFACTURED BY:
NICOLET INDUSTRIES, INC.
70 Pine Street
New York 5, N. Y.

DISTRIBUTED BY:
MIDDLE WEST COATING & SUPPLY
207-A Daniel Bldg.
P. O. Box 153
Tulsa, Okla.
PH. 2-5215
or 2-5216

Write for Rates, 1061 M & M Bldg.
Houston 2, Texas

CORROSION DIRECTORY

Over 5000 Paid
Readers Monthly

Cathodic Protection

ALL-CO CATHODIC PROTECTION

Design • Installation • Surveys
Equipment • Supplies

ALLEN CATHODIC PROTECTION CO.

P. O. Box 386 Phone EDison 2081
HARVEY, LOUISIANA

Cathodic Protection Service

Engineering • Installation • Surveys
Material • Supplies

Everything in the Cathodic Protection Field from
an Insulating Washer to a Turnkey Contract
Installation

4601 Stanford — HOUSTON — Phone JA 5171
NEW ORLEANS TULSA
1639 Robert St. 310 Thompson Bldg.
Phone CH-8310 Phone 2-9857

CORROSION RECTIFYING CO.

1506 ZORA ST. VA 7522 HOUSTON

CATHODIC PROTECTION

SURVEYS — DESIGN — INSTALLATION

- Pipe Lines • Offshore Platforms
- Refinery & Gasoline Plant Lines
- Municipal Systems • Barges

CORROSION SERVICE LIMITED Offers in CANADA

A Complete Service in Corrosion Engineering,
Design and Installation of Cathodic Protection
Systems.

Resistivity and Electrolysis Surveys,
Selection and Application of Protective Coatings.
Rectifiers — Anodes — Materials

77 York St., Toronto, Canada

CATHODIC PROTECTION

Surveys Engineering
Installation Maintenance

Electro Rust-Proofing Corp. (N. J.)

BELLEVILLE 9, NEW JERSEY
Atlanta — Chicago — Dallas — Monrovia

• Complete CATHODIC PROTECTION

Systems . . . supplies . . . service
for special applications; water tanks
and pipe lines.

HARCO CORPORATION

16901 Broadway Cleveland, Ohio

Cathodic Protective Systems Designed and Installed

Coating and Laying Specifications;
Corrosion Surveys; Consultation On
All Types of External Pipe Line Corrosion.

Huddleston Engineering Co.

Bartlesville Oklahoma

Cathodic Protection

Pipeline Maintenance

Again in 1952, we lead all contractors in
Magnesium Anodes installed

LET US SHOW YOU WHY

CATHODIC PROTECTION — INSTALLATION —
ENGINEERING — SURVEYS
(Complete job or installation only)

PIPELINE *Maintenance* CORPORATION
3-8126 TULSA, OKLAHOMA BOX 1424



Dependable Selenium Rectifiers for Cathodic Protection

are manufactured by

Richardson-Allen Corporation

a manufacturing affiliate of

WESLEY BLOCK AND COMPANY

39-15 MAIN STREET, FLUSHING, NEW YORK
IN CANADA: Richardson-Allen of Canada, Ltd.,
370 Victoria St., Toronto, Ontario

RIO ENGINEERING CO.

Cathodic Protection Systems

Surveys Installation Design

HOUSTON, TEXAS
3607 Yoakum KE 9792

CATHODIC PROTECTION

Distributors and Contractors

- T. D. Williamson Casing Insulation
- Good-All Rectifiers • Dow Magnesium Anodes • National Graphite Anodes • Instruments and Insulation • Contract Anode Installations.

STUART STEEL PROTECTION CORP.
Kenilworth New Jersey

Coatings and Linings

CORROSION ENGINEERING

Let us select and apply the coating
or lining best suited to protect your
equipment and structures.

A & P FINISHING & MFG. CO.

17760 Clarann Avenue
Melvindale (Detroit) Mich.

CORROSION-PROOF

LININGS
CEMENTS
BRICK



- TANKS, FLOORS, FUME DUCTS
AND PROCESS EQUIPMENT
- COMPLETE LINE OF
PROTECTIVE COATINGS..

Over a Quarter Century of Experience



CORROSION-PROOF
MATERIALS • CONSTRUCTION • SUPERVISION

The CEILCOTE Co. 4844 N. HIGHWAY 10, CLEVELAND 9, OHIO

Advertise In the
CORROSION DIRECTORY
After Jan. 1, 1953, \$75

Coatings and Linings

HARTMAN—HANKS—WALSH PAINTING COMPANY

5078 Easton Ave. St. Louis 13, Mo.
Cable APCO—Phone FOREST 6222

SPECIAL COATINGS APPLICATORS

- Sandblasting Painting
- Perma-Skin Anti-Corrosion Vinyl Coatings
- Spring-Kate Corrosion Resistant Mastics
- Dunn-Dum Masonoc — A Complete Spray Painting Service

Engineering Service

DEUBER LABORATORIES

Bacterial Corrosion Fungus Resistance Tests
Soil Performance Tests of Coatings, Tapes, etc.

Industrial Research

114 East 32nd Street Telephone:
New York 16, N. Y. LEXington 2-3244

CORROSION ENGINEERING

SURVEYS • DESIGNS • SPECIFICATIONS

Impartial Evaluation

THE HINCHMAN CORPORATION

Engineers

Francis Palms Bldg., Detroit 1, Mich.

Instruments

INSTRUMENTS

For the Corrosion Engineer

- Copper Sulfate Electrodes
- Resistivity Rod & Pipe Prod
- AC Bridges
- No Current Potentiometer with Current Ranges

J. L. COLLINS ANGLETON, TEXAS

Pipe Coating and Wrapping

SERVING ALL PIPELINES

PIPELINE ASBESTOS FELT

Made by The Ruberoid Co.

COAL TAR ENAMEL COATINGS

Made by Pittsburgh Coke & Chem. Co.

FIELD JOINTERS

Made by American Coating Supply Co.

"Steve" Day

S. D. DAY COMPANY

1973 W. Gray Houston 19, Tex.
Phone JU-2431

Complete Corrosion Mitigation
Product and Equipment Line
WE REPRESENT: Koppers Coatings, Nicolet
Asbestos Pipe Line Felts, Apex Magnesium
Anodes, National Graphite Anodes, Tapecoat.

- Rectifiers • Instruments
and other nationally known products

MIDDLE WEST COATING & SUPPLY

TULSA, OKLA.

207-A Daniel Bldg. Phone: 2-5215

The 1953 Conference and Exhibition
of the National Association of Corrosion
Engineers will be held March 16-20
with headquarters at the Sherman Ho-
tel, Chicago.

POSITIONS WANTED and AVAILABLE

- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

Positions Wanted

Corrosion Engineer, 6 years pipe line experience. Design, construction, operation, maintenance cathodic protection systems. Single. Do not mind extensive travel. Write Corrosion Box 53-1.

Chemical Engineer, former plant engineer, research chemist, presently engaged formulation, sales, application phenolic, vinyl, copolymer resins. Eight Middle Atlantic states past 5 years handling chemical, paper, textile and allied industries. Earning \$12,000. Chemical resin sales preferred. CORROSION Box 53-2.

Electrical Engineer, BSEE, 37, married. Veteran. Experience estimating, design, supervision of installation of power, control, telemetering, carrier, radio, instruments, cathodic protection, etc. industrial and gas pipe line. Summary on request. CORROSION Box 53-3.

Positions Available

Chemical Engineer—Familiar with materials of construction and corrosion problems to be technical staff man to evaluate and recommend, also develop methods for mfg. chemical-proof equipment. Advise experience and salary desired. Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio.

Corrosion Engineers. Positions available for graduate electrical engineers or equal. Previous field and design experience in corrosion mitigation systems required. Extensive travel involved. Salary open. The Hinchman Corp., Engineers, Francis Palms Bldg., Detroit 1, Mich.

Corrosion Chemist: Industrial laboratory performing metallurgical research requires men to initiate and carry out fundamental inquiries pertinent to mechanism of corrosion of metals in various corroding media. Develop testing tech-

NEW PRODUCTS—Materials—Service—Literature

(Continued From Page 51)

9, Ohio from which copies may be obtained on request. The 4-page bulletin gives full information on basic compositions, and characteristics of Tygon gasketing.

International Nickel Co., Inc., 67 Wall Street, New York 5, N. Y. has published two technical booklets listing literature which can be obtained from the company. The publication List A contains abstracts of articles for production men, design engineers, metallurgists and metal users. Under the heading Corrosion are articles titled: Corrosion By Some Organic Acids and Related Compounds; The Behavior of Nickel Copper Alloys in Sea Water; Some Observations of the Potentials of Metals and Alloys in Sea Water, and Controlling Factors in Galvanic Corrosion; The Behavior of Iron Modified 70-30 Cupro-Nickel Alloy in Salt Water and in Some Petroleum-Industry Environments; The Effect of the Iron Content of Cupro-Nickel on Its Corrosion Resistance in Sea Water and A Critical Look at Salt Spray Tests. In other parts of the booklet are abstracts of: Atmospheric Durability of Steels Containing Nickel and Copper; Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels; A Theory of the Mechanism of Rusting of Low Alloy Steel in the Atmosphere and High Corrosion Resistance Gives Nickel Plated Metals Wide Range of Uses.

The second technical booklet lists literature on various alloys made by INCO which the company will send to those requesting it. In the corrosion section of this booklet are 16 abstracts. Among them are: Resistance of Monel, Nickel and High-Nickel Alloys to Corrosion by Sulfuric Acid; The Resistance of Nickel and Its Alloys to Corrosion by Caustic Alkalies; Corrosion Testing Methods; The Resistance of Nickel, Monel and Other High-Nickel Alloys to Corrosion by Hydrochloric Acid, Hy-

niques for investigating electrochemical phenomena which may be involved in the corrosion of various metals in different environment. Ultimate objective of research is the origination of new alloys with superior corrosion resistance and the development of treatments that will enhance the corrosion resistance of present materials. Please send outline of qualifications, personal background and educational summary. CORROSION, Box 53-4.

drogen Chloride and Chlorine; The Behavior of Nickel and Monel in Outdoor Atmospheres; Corrosion and the Final Choice; Aspects of Galvanic Corrosion; Corrosion: Processes-Factors-Testing; Corrosion Data Work Sheet; How to Recognize and Control Concentration-Cell Corrosion; and Planning and Interpreting Corrosion Tests. Attached to booklet A is an order envelope with prepaid postage so that the desired article may be checked. On the back cover of booklet B is a form for writing to the company asking for help with corrosion problems of the reader.

Perrault Brothers, Tulsa, has sold its pipe line equipment division to W. O. Dixon. Perrault Equipment Co. will continue to manufacture coating and wrapping machines, pipe coatings and wrappings and supplies. Perrault Brothers Fibercast Corp. manufactures Fibercast oil well tubing and line pipe.

Michigan Plastic Pipe Company, Detroit, Mich. has begun extrusion of Tuffite rigid and flexible pipe at its Melvindale plant.

Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland, Ohio has issued a new Bulletin 460 describing a wide range of acid-proof lining materials.

"**Erkoprene 900**," an improved neoprene-based coating is announced by Earl Paint Corp., 240 Genesee St., Utica, New York. The firm says Erkoprene 900 is a self-vulcanizing, neoprene-base synthetic rubber coating of high concentration, making possible a greater thickness per application, as much as .02 inches per brush coat. It is ideal for lining tanks handling acids and other corrosive chemicals and has all the physical properties of vulcanized rubber—toughness, resistance to abrasion, elasticity, strength and chemical resistance. It is inert to all acids with the exception of the highly oxidizing ones such as nitric and chromic. It will withstand sulfuric acid in concentrations below 50 percent, and is superior to natural rubber in resistance to oils, fats and solvents. Suggested other uses of Erkoprene are as a protective coating or lining for impellers, mixers, paper mill equipment, fan blades, pipes, pump bodies, etc., as well as to protect structural members subject to splash or spray of corrosives and for general maintenance painting.

Fermex Company, 11 Hill St., Newark 2, (Continued on Page 54)

Write for Rates, 1061 M & M Bldg.
Houston 2, Texas

CORROSION DIRECTORY

Over 5000 Paid
Readers Monthly

Pipe Coating and Wrapping

PIPE COATING "KNOW-HOW" by PIPE PROTECTION SERVICE, Inc.

Modern Portable Railhead
Equipment for Any Size Pipe or Job

Main Plant: 179 FRONT ST., ELIZABETH, N.J.
"The Complete Coating Service"

Testing

South Florida Test Service

INSPECTION - TESTING - RESEARCH
ENGINEERS
(Established 1931)

Corrosion, weathering and sunlight tests.
Four locations in Southern Florida for inland,
salt atmospheric, tidalwater and total immer-
sion exposure tests.

4201 N. W. 7th St. MIAMI, FLORIDA

Water and Steam

WATER SERVICE LABORATORIES, INC.

Specializing Since 1927

Water treatment for corrosion
control in buildings, boilers and
air conditioning systems.

Main Office—423 West 126 Street, NYC
Offices also in Phila. and Wash., D. C.

NEW PRODUCTS

(Continued From Page 53)

N. J. is producing a newly discovered active ingredient which has been combined with a special fermentation process to continuously reduce organic waste to a liquid, providing a year around, trouble-free septic tank operation in a single application per year. It is said to be non-corrosive to pipes, porcelain or concrete block.

Atlstavon 20, a new type of plasticized polyvinyl chloride sheet is being produced by Atlas Mineral Products Co., Mertztown, Pa. and Houston, Texas. It is said to be resistant to alkalis, corrosive salts and to most acids including

nitric and chromic. It is applied by a new technique.

Kelon fluoroplastic production will be increased 300 percent in the W. S. Shamban Co., 11617 W. Jefferson Blvd., Culver City, Cal. plant.

Stainless Steel screw conveyors, carried in stock in 6-inch diameters with a 6-inch pitch, 9 to 10 feet long, are offered by M. H. Standard Co., 515 Communipaw Ave., Jersey City 4, N. J.

Vitri-Cor, a new enameled steel roofing made on a corrugated steel base is being manufactured by Toledo Porcelain Enamel Products Co., Renkert Building, Canton, Ohio. Marketed as Vitric-Steel by Republic Stamping and Enameling

Co. since 1939, the basic process was taken over by Toledo when Republic decided to suspend its manufacture.

Bar-Ray Products, Inc., 209 Twenty-Fifth St., Brooklyn 32, N. Y. has issued a 72-page catalog of accessories for protection against X-ray and radiation. Copies are available on request.

Mills III, a transparent cellulose acetate butyrate pipe in sizes from 1/2-inch through 4 inches is available for laboratory and pilot plant use. Sections are joined by a solvent cement. Plastic fittings are available also from the manufacturer, Elmer E. Mills Corp., 3930 North Ashland Ave., Chicago 13, Ill.

Soiltest, Inc., 4522 W. North Ave., Chicago, formerly a division of Soil Testing Services, Inc., will devote itself to design, manufacture, sales and distribution of physical testing apparatus for soils, asphalts and concrete.

Bowser Technical Refrigeration, Terryville, Conn. has issued descriptive bulletins on its units for treatment of metals to -200 degrees F or lower. Information on specific applications of cold treatment to metal manufacturing are included.

Polyken Protective Tape Coatings No. 900 and No. 910, with a 8-mil film, compared to the former 7-mil film, greater tear resistance, tensile strength and a very low vapor transmission rate are now being manufactured by Polyken Industrial Tape Dept., of Bauer & Black, 222 West Adams St., Chicago 6, Ill. The adhesive mass has been increased from 2 to 4 mils. Descriptive literature and samples are available on request.

Type 304 Stainless steel needle tubing, originally developed for surgical uses, is available in tempers which make it suitable for industrial uses. An article "Use of Needle Tubing Extended to Mechanical Applications" describing its uses is available from Superior Tube Co., Norristown, Pa.

Coast Paint and Lacquer Co., P. O. Box 1113, Houston has issued a folder describing its Copon coatings, made from Epon resins.

Piccopale, a new low cost, basic petroleum raw product, developed by Pennsylvania Industrial Chemical Corp., Clairton, Pa. is available in huge quantities. The 100 percent polymerized petroleum resin is available as a solid, flaked and in solution. The manufacturer claims it has good chemical resistance, is readily soluble and is compatible with a wide range of products. A brochure describing its characteristics is available on request.

Wilputte Coke Oven Division of Allied Chemical and Dye Corp. designed the heat transfer equipment in the United States Steel Corporation's Fairless Works coke by-products plant.

"Manufacture of Liquid Sulfur Dioxide," Lead Chemical Construction Bulletin No. 6, is available from Lead Industries Association, 420 Lexington Ave., New York 17, N. Y.

AT LAST! AN ECONOMICAL, SHOCK RESISTANT INSULATING COUPLING

Until recently mechanical weakness and high costs have discouraged the large-scale use of insulating couplings on gas distribution systems. Now comes PESCO . . . safe, economical, rugged, easy to install, and assuring permanent electrical insulation.



Insulate your distribution system with PESCO INSULATING COUPLINGS*

PESCO couplings are designed and built to stand up under all types of extreme operational conditions. They are molded of nylon under high pressure. Nylon is a thermoplastic resin which is comparable to thermosetting resins in physical properties and far superior in chemical resistance and the ability to withstand bending, side thrust and shock. They stand pressures up to 1100 psi and are not affected by temperatures up to

300°F. Molding forms perfect threads and a "di-electric wall" inside the coupling to provide fool-proof electrical insulation and added sealing ability. A special locking device prevents the coupling from turning or slipping in its steel sleeve.

PESCO couplings may be installed by your regular workmen with their standard operating procedures. Available in all sizes from 3/4" to 2".

* Patent Pending

PLASTIC ENGINEERING AND SALES CORP.
P. O. BOX 1037 FORT WORTH, TEXAS

PERSONALS

W. M. Coopman, former division chief engineer for Republic Supply Corp., has been appointed district engineer for Marlow Pumps, Ridgewood, N. J. Headquarters for Mr. Coopman will be in Burbank, Cal. The firm has created a new territory consisting of Southern California, Nevada, Utah and Arizona.

James H. Baldrey has been appointed supervisor of melting for the Cooper Alloy Foundry Co., Hillside, N. J. He has been associated with the Watervliet plant of Allegheny Ludlum Steel Co. for the past 18 years. In 1939 he became manager of melting. His special metallurgical interest has been in the melting of stainless steels and developing systematized controls to lessen rejects and maintain quality. He is current president of the Electric Metal Makers Guild and is a member of the American Society for Metals, the American Institute of Mining and Metallurgical Engineers and the Industrial Club. He is a graduate of Rensselaer Polytechnic Institute.

Glenn H. McIntyre and **Orville O. Kenworthy** have been appointed to new key posts with the Ferro Corporation. Dr. McIntyre was named technical director of the corporation and Mr. Kenworthy was appointed director of research. Dr. McIntyre will supervise the technical work of all branches, divisions and subsidiaries of Ferro Corp. He is also vice-president of the firm. Two other staff appointments have been announced. **E. E. Bryant** was made technical director of the porcelain enamel division and **Grant E. Miller** was named to the post of director of enamel development, a position formerly held by Mr. Bryant.

Martin H. Smith, formerly of Hercules Powder Co., has joined the technical service department of the Atlas Mineral Products Co.

Dendall B. Rowell has been appointed chief engineer of the American Locomotive Co. He will be responsible for product development and engineering in the company's Locomotive Division, Schenectady, N. Y.

Louis F. Long, Jr., has been appointed technical service director of The Glidden Company's industrial region, it was announced by G. S. Forbes, regional manager. Mr. Long joined the Glidden Co. in 1947 as assistant manager of aviation sales.

Jack O. Abney is the new associate works manager for the Penn Metal Co., Inc., of New York and Boston, manufacturers of building products and expanded metal. Mr. Abney will have charge of research and development at the firm's Parkersburg, West Virginia plant. Mr. Abney was formerly director of standards and methods engineering, Chevrolet Division of General Motors Co. in Indianapolis.

John C. Tyler has been named southern regional manager for the Insul-Mastic Corp. of America, Pittsburgh 22, Pa. Mr. Tyler will be located in the company's Houston office and will travel throughout the South and the Gulf Coast

area to provide sales and technical assistance to Insul-Mastic licensees. The company manufactures heavy protective coatings which are applied to metal, and masonry and insulation for protection from corrosive and other destructive elements.

Fred Whittier, a member of NACE, has been promoted to supervisor of the bituminous coatings research and development department at Neville Island, Pa., for the Pittsburgh Coke & Chemical Co., Pittsburgh, Pa. Mr. Whittier's previous post was supervisor of coal tar chemical process improvement in the firm's production department. He came to Pittsburgh Coke & Chemical in 1951 from the U. S. Testing Co. He is also a member of the American Chemical Society.

Frederick W. Fink, corrosion technologist at Battelle Institute, Columbus, Ohio, is new chairman of the corrosion division of the Electrochemical Society.

John S. Hackett has been put in charge of the newly developed Transportation Division of The Debevoise Company.

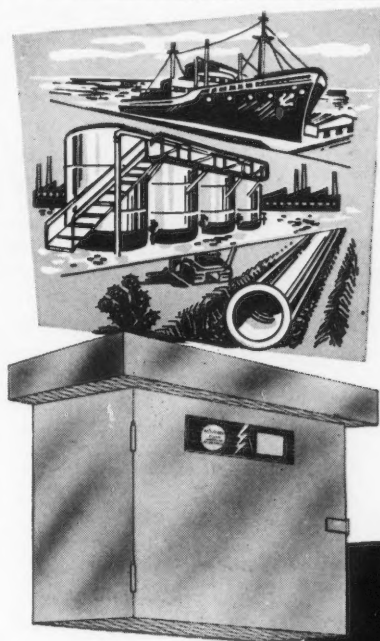
William Barnack, Jr., has been named assistant chief chemist by The Debevoise Company. Mr. Barnack, a 1949 graduate of Pratt Institute is a member of ACS and the New York Paint and Varnish Production Club.

Thomas F. P. Kelly has been named a partner in the firm of James E. Mavor Company and the firm name has been changed to Mavor-Kelly Company.

FIGHT CORROSION

with SPECIAL EQUIPMENT to meet YOUR NEEDS

Cathodic Protection from a Dependable D C source



RICHARDSON ALLEN SELENIUM RECTIFIERS

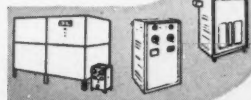
Whether it's overhead or underground, in humid or dry atmosphere, on the seacoast or in the interior — combat corrosion with cathodic protection and provide for utmost dependability by installing Richardson-AlLEN Selenium Rectifiers.

A sound basic design with high quality of construction, and many features of superiority assure continuous, uninterrupted service.

Let us prove to you the dependability of Richardson-AlLEN equipment for your application. Tell us about your present needs and let us submit a quotation.

RICHARDSON-ALLEN CORPORATION

a manufacturing affiliate of
WESLEY BLOCK AND COMPANY, 39-15 MAIN ST., FLUSHING, N. Y.
IN CANADA: Richardson-AlLEN of Canada, Ltd., 370 Victoria St., Toronto, Ont.



SET IT and FORGET IT

BOOKS, PAMPHLETS and REPRINTS of MATERIAL on CORROSION

● BOOKS

Joint Symposium on Cathodic Protection

Postpaid to members ECS and
NACE, per copy.....\$ 6.00
To all others, per copy..... 8.00

Bibliographic Survey of Corrosion, 1945

Postpaid to NACE members,
per copy.....\$ 4.00
To others, not NACE members,
per copy..... 5.00

Bibliographic Survey of Corrosion, 1946-47

Postpaid to NACE members,
per copy.....\$ 7.00
To others, not NACE members,
per copy..... 9.00

1945 and 1946-47 Bibliographies Combined

Postpaid to NACE members...\$ 9.00
To others, not NACE members... 12.00

● BOOKLETS

Control of Pipe Line Corrosion by O. C. Mudd

Per Copy, postpaid.....\$ 1.25
(5 or more copies to one address,
per copy, \$1)

Report of the Correlating Committee on Cathodic Protection

1 to 10 copies, each..... 50c
11 to 100 copies, each..... 35c
More than 100 copies, each..... 25c
Postpaid

Symposium on Sulfide Stress Corrosion

Publication 52-3
Per Copy, postpaid.....\$ 1.00
(5 or more copies to one address,
per copy, 50c)

NACE Committee Directory

Publication 52-2
Per Copy, postpaid, members...\$ 1.00
(Non-members of NACE, \$2)



● TECHNICAL REPORTS

TP-3 First Interim Report on Ground Anode Tests

Publication 50-1
Postpaid to NACE members, per copy.....\$ 3.00
To others, not NACE members, per copy..... 5.00

TP-2 First Interim Report on Galvanic Anode Tests

Publication 50-2
Postpaid to NACE members, per copy.....\$ 3.00
To others, not NACE members, per copy..... 5.00

TP-1 Report on the Field Testing of 32 Alloys in the Flow Streams of Seven Condensate Wells

Publication 50-3
Postpaid to NACE members, per copy.....\$ 8.00
To others, not NACE members, per copy..... 10.00

Report of TP-12 on Electrical Grounding Practices*.....50

First Interim Report of TP-6G on Surface Preparation of Organic
Coatings. Publication 50-5.....50

Report of TP-5C Sub-Surface Corrosion by Alkaline Solutions.*
"Stress Corrosion Cracking in Alkaline Solutions." Publication
51-3.....50

Report of TP-1 on Sour Oil Well Corrosion, per copy.....50

* Available only in limited supply.

● REPRINTS

Cathodic Protection and Pipe Lines
Mitigation of Corrosion on City Gas Dis-
tribution Systems by A. D. Simpson, Jr.50

Paints and Coatings
Gasoline Resistant Tank Coatings
by W. W. Cranmer.....50
Tests, Properties of Corrosion Preventive
Lubricants for Lead Sheathed Cables in
Underground Ducts—A Discussion by
Howard S. Phelps and Frank Kahn.....50

Petroleum Production and Storage
Corrosion in Condensate and in High Pres-
sure Sweet Oil Wells by R. C. Buchan.....50
The Use of Ammonia in Control of Vapor
Zone Corrosion of Storage Tanks* by
F. T. Gardner, A. T. Clothier and F.
Coryell.....50

Miscellaneous
Causes of Corrosion in Airplanes and Meth-
ods of Prevention by N. H. Simpson.....50
Cathodic Protection of an Active Ship in
Sea Water* by K. N. Barnard and G. L.
Christie.....50
Salt Spray Testing Bibliography by Lor-
raine Voight.....50
The Cost of Corrosion to the United States
by H. H. Uhlig.....50
Why Metals Corrode by H. H. Uhlig.....50
Corrosion Control by Magic—It's Wonder-
ful by H. H. Uhlig.....50
Index to Volume 8.....50

● SINGLE COPIES OF CORROSION

Single copies of Corrosion are available
at 50c a copy to NACE members and \$1
a copy to non-members, postpaid.

Copies of all issues are available except:
1947—January, March, July, September,
November

1948—February, May, June, July,
August, December

1949—January, February, July, August,
September, October

1950—January, February, April, May,
July, August, December

1951—January, February
1952—March

Indices to Corrosion technical literature have
been published as follows:

5-Year Index, 1945-49 inclusive and
Index to Vol. 6, 1950..... December, 1950
Index to Vol. 7..... December, 1951
Index to Volume 8..... December, 1952

Address Orders and Remittances to

NATIONAL ASSOCIATION of CORROSION ENGINEERS

HOUSTON

1061 M & M Building

TEXAS



Corrosion Abstracts

Index to CORROSION ABSTRACTS

Vol. 9 February, 1953 No. 2

	Page
3. CHARACTERISTIC CORROSION PHENOMENA	
3.7 Metallurgical Effects	11a
3.8 Miscellaneous Principles	12a
4. CORROSIVE ENVIRONMENTS	
4.3 Chemicals, Inorganic	12a
4.5 Soil	12a
5. PREVENTIVE MEASURES	
5.3 Metallic Coatings	12a
5.4 Non-Metallic Coatings and Paints	13a
5.9 Surface Treatment	13a
5.11 Design—Influence on Corrosion	14a
6. MATERIALS OF CONSTRUCTION	
6.1 General	15a
7. EQUIPMENT	
7.2 Valves, Pipes and Meters	15a
7.3 Pumps, Compressors, Propellers, Impellers	16a
7.5 Containers	16a
7.6 Unit Process Equipment	16a
8. INDUSTRIES	
8.4 Group 4	18a
8.5 Group 5	18a
8.8 Group 8	18a
8.9 Group 9	18a

• NOTE: For further information on the NACE Abstract Filing Index see December, 1952 issue of Corrosion. Industries in the groups coded under 8 are listed in this issue.

Investigate Other Abstract Services Offered by NACE!

Abstract Punch Card Service.

Corrosion abstracts printed on McBee Punch Cards, pre-indexed by the NACE Filing system with up to 4 cross-references. Write for full information.

Bibliographic Surveys of Corrosion.

Abstracts in book form. Indexed and cross indexed by topics. Author Index. A valuable aid for corrosion workers. See advertisement this issue for added information.

NATIONAL ASSOCIATION of CORROSION ENGINEERS

1061 M & M Bldg. Houston, Texas

3. CHARACTERISTIC CORROSION PHENOMENA

3.7 Metallurgical Effects

3.7.3, 6.4.2

Fabrication of Corrosion Resistant Metal. The Importance of Metallurgical Control. J. F. LANCASTER, *Welding and Metal Fabrication* (England), 19, No. 6, 202-209 (1951) June.

Manual fusion welding of aluminum and its alloys, sheet and plate thicknesses up to $\frac{1}{2}$ inch is discussed. Gas welding is most often used for welding pure aluminum. It is applicable to any thickness of sheet in both the downhand and vertical position, and requires the minimum of joint preparation. Since most effective fluxes are corrosive, the joint must be designed to avoid any potential flux traps and must be cleaned after welding. Metallic arc welding, using a flux-covered 5 per cent-silicon core wire, is only fairly satisfactory and the pure aluminum electrode is most difficult of all to control. Argonarc welding is most advantageous, since the use of a flux is eliminated, but the high cost must be offset by some other economy. Aluminum alloy NS3 may be classed as pure aluminum for welding purposes. Gas welds of aluminum-magnesium alloys of 3 and 5 per cent magnesium are less satisfactory, for gas porosity and cracking trouble are often present. Metallic arc welding reduces the extent of the porous zone, but the weld efficiency is no greater. Argonarc welds are relatively free from porosity, and it is possible to obtain weld efficiencies of 95 to 100 per cent without any modification of the technique used for aluminum. The magnesium-silicide alloy has

Sources of PHOTOPRINTS and/or

MICROFILM COPIES

of Technical Articles Abstracted in CORROSION ABSTRACTS

ENGINEERING SOCIETIES LIBRARY,
29 West 39th Street, New York 18,
N. Y.

CARNEGIE LIBRARY OF PITTSBURGH,
4400 Forbes St., Pittsburgh 13, Pa.
NEW YORK PUBLIC LIBRARY, New
York City.

U. S. DEPT. OF AGRICULTURE
LIBRARY, Office of Librarian, Wash-
ington, D. C. (Special forms must be
secured).

LIBRARY OF CONGRESS
Washington, D. C.

JOHN CRERAR LIBRARY
86 East Randolph St.,
Chicago 1, Ill.

Persons who wish to secure copies of articles when original sources are unavailable, may apply directly to any of the above for copies. Full reference information should accompany request. The National Association of Corrosion Engineers offers no warranty of any nature concerning these sources, and publishes the names for information only.

NACE will NOT accept orders for photoprint or microfilm copies of material not published by the association.

CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating, 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W.1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England, 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana. Associazione Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

a pronounced cracking tendency and cannot be gas welded satisfactorily. Apart from this drawback, the HS-10 alloy welds more satisfactorily than the aluminum-magnesium alloy, the oxide film being less tenacious and penetration easier to control. Weld metal, which is essentially in the chill-cast condition, is more sensitive to corrosion than the parent sheet. This is probably due to the segregation of alloying elements, as illustrated in the corrosion of aluminum alloys in concentrated nitric acid.—ALL.

3.8 Miscellaneous Principles

3.8.2, 5.4.5, 6.2.3

Electrochemical Behavior of Paint Films in Sea Water. J. E. O. MAYNE. *Chemistry & Industry*, No. 15, 293-294 (1951) Apr. 14.

On the basis of tests made on coated and uncoated mild steel samples, it can be seen that the coated specimens were always cathodic to the uncoated ones. The potential of uncoated steel immersed in sea water is a compromise potential. The probable explanation of this does not cause any breakdown of the principle of Differential Aeration, as do other explanations that have been put forth in regard to the electrochemical behavior of painted steel surfaces. Tables. 7 references.—INCO.

3.8.3, 3.8.2

H. H. Uhlig's Electron-Configuration Theory of Passivity: A Critical Evaluation. (In German.) THEO HEUMANN. *Z. Elektrochem.*, 55, 287-295 (1951) May.

Shows that, except for nickel, the known physical properties of metals and alloys indicate that the electron exchange demanded by above theory is highly improbable, that any electron exchange would be opposite to that indicated by the theory, and that in heterogeneous alloys their phase states must be considered. Includes graphs and tables. 37 references.—BLR.

4. CORROSIVE ENVIRONMENTS

4.3 Chemicals, Inorganic

4.3.5, 6.3.10, 7.5.5

Victory Over Bromine. ALBERT R. JASUTA. *Food Machinery And Chemical Corp. Modern Packaging*, 24, 117-121 (1951) June.

Story of the new Monel drum developed for handling Br₂. Formerly glass bottles and lead lined steel containers were used but had many disadvantages. Materials subjected to corrosion tests in the investigation were carbon steel, lead, Teflon, Hastelloy A, B and C, Monel, nickel, polyethylene, Dow Metal M and Haynes Stellite 19 P. Only Monel, Nickel and Teflon proved adequate for the containers. Teflon, though completely resistant to bromine, could be used only as a closure gasket material because of its high cost. Corrosion tests on Monel and nickel were continued and after a 6 month period a corrosion rate of 0.00013 ipy was calculated for Monel, which was considered low enough. The interior of the drum had rings of a slight corrosion at gas-liquid interfaces, but there was no evidence of pitting or severe localized cor-

rosion. After successful impact tests the Monel drum was adopted. A nickel drum was not adopted because it had a welded chime and the Monel was slightly cheaper. The container is a 10 gallon drum constructed of 14 gauge Monel metal. The construction of the drum is outlined. A diagram of the drum, results of the bromine corrosion tests, a comparison of practicable bromine containers and a suggested method of emptying the drums are given.—INCO.

4.5 Soil

4.5.2, 6.1

Materials and Soils. (In German.) L. W. HAASE. *Werkstoffe u. Korrosion*, 2, No. 3, 90-93 (1951) Mar.

Discusses the corrosive effects of different types of soil on iron, copper, zinc, lead, and their alloys; also the chemical effects of soils on cement, asbestos cement, concrete, ceramics, and wood. Includes diagrams and photographs.—BLR.

5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.1, 5.4.1, 5.9.1

Electrolytic and Chemical Finishes. *Product Eng. (U.S.A.)*, 22, No. 2, 141-148 (1951) Feb.

A comprehensive survey of chemical and electrochemical finishes for metals, with colored illustrations. A short section describes finishes for zinc, and the application of zinc and cadmium coatings to ferrous metals is also discussed. An extensive table summarizes the chief properties and special features of application of 20 kinds of finish.—ZDA.

5.3.2, 1.3

The Protective Value of Chromium Deposits. *Galvano Tecnica*, 11, No. 4, 95-100 (1951).

A review of continental literature as an assessment of the corrosion resistance of decorative and protective chromium plate.—EL.

5.3.2, 5.3.4

The Corrosion-Resistance of Nickel and Chromium Electrodeposits. III.—How to Produce a Satisfactory Coating. J. LIGER. *Galvano (Fr.)*, 20, No. 168, 11-14 (1951). Cf. *ibid.*, 19, No. 167, 11 (1950).

The factors contributing to the production of a satisfactory nickel electrodeposit are considered. They include coating thickness, plating solution, operation and control. Copper plating before nickel deposition, and surface preparation and polishing.—MA.

5.3.4

Pitted Cadmium on Aluminum. *Metal Finishing*, 49, No. 3, 75 (1951) March.

In answer to a reader's query about the causes of pitting in aluminum articles after nickel/cadmium plating. Suggestions are made for findings whether the pitting is due to faults in the nickel or the cadmium. It is considered possible that the trouble may result from air bubbles in the cadmium solution introduced in the course of pumping and filtering, which is said to be of no advantage in cadmium plating.—ZDA.

5.3.4

Progress in Metal Spraying Equipment. H. J. PLASTER. *Electroplating and Metal Finishing*, 4, No. 7, 215-217 (1951) July.

A description of the development of automatic metal spraying equipment for treating large quantities of similar articles. Examples of products which are zinc sprayed automatically include radio valves and the Sargrove radio circuit.—ZDA.

5.3.4, 5.3.2

Experiments in Chromium Plating from Non-Aqueous Media. A. L. HANSON, D. FROKJER, AND D. MITCHELL. *Metal Finishing*, 49, No. 4, 48-49, 69 (1951).

Experimental details are presented of attempts to deposit chromium from a number of organic materials. The most satisfactory were: (i) formamide, (ii) acetamide, and (iii) acetamide-urea mixture. Less satisfactory were acetic acid and ethanolamine, and very little success was obtained with acetonitrile and dimethyl formamide. It is shown that Cr³⁺ will deposit more effectively than non-aqueous solution than will Cr⁶⁺. Current density of 5-15 amp./dm.² were required to produce satisfactory deposits. The addition of a little sulfuric acid to the baths increased the conductivity, but it had no appreciable effect on the plating when Cr³⁺ was used though it improved it when Cr⁶⁺ was used. 4 references.—MA.

5.3.4, 5.3.2

The Technique and Uses of Zinc Spraying. (In French.) F. HEDDE. *Bull. Documentation Technique. Zinc et Allages*, Paris, Feb. 1951, p. 508.

Notes on some of the practical details of zinc spraying by the wire process and followed by an account of the properties and uses of sprayed zinc coatings, with emphasis on their advantages over other protective coatings. Finally reference is made to some of the most important applications of sprayed zinc in the French navy, on the railways, in civil engineering in aircraft, in building and in electricity distribution.—ZDA.

5.3.4, 5.4.8

The Industrial Applications of Electrodeposited Coatings. P. MORISSET. *Usine Nouvelle*, 1951 (Numéro spécial), 73, 75, 77, 79-80.

A comprehensive survey of the characteristics and industrial application of electrodeposited coatings. A number of particularly useful tables are included. In the first of these the minimum and average coating thickness is specified when the metal coating is plated on to steel, zinc, copper, and aluminum and their respective alloys intended for industrial or decorative purposes. The electrodeposited metals include nickel (with a copper undercoat), chromium after nickel plating, copper, zinc, cadmium, lead and tin (on copper deposits), zinc-tin (80:20), silver and gold (on copper deposits), rhodium, platinum, and palladium (on nickel or gold). References are given for these specifications. Further tables show recommended nickel coating thicknesses for different corrosive conditions relative to housing and motor cars and when applied to iron, copper, zinc, and aluminum and their respective alloys. The properties of the electrodeposited coatings are briefly described; hard nickel and chromium plating receive detailed attention.—MA.

5.4 Non-Metallic Coatings and Paints

5.4.2, 3.5.9, 6.2.1, 6.3.1

Effectiveness of Ceramic Coatings in Reducing Corrosion of Five Heat-Resistant Alloys by Lead-Bromide Vapors. D. G. MOORE AND M. A. MASON. Natl. Bur. Standards. Natl. Advisory Committee for Aeronautics, Technical Note 2380, June 1951, 27 pp.

A study is presented of the corrosive attack of lead bromide in an air atmosphere on uncoated, preoxidized, and ceramic-coated (including NiO and CoO) specimens of heat resistant alloys, Inconel (78 nickel, 14 chromium, 7 iron), sulfur-816 alloy (20 nickel, 20 chromium, 44 cobalt, 4 molybdenum, 4 wolfram (tungsten), 4 columbium, 3 iron), H.S. 21 (28 chromium, 2.5 nickel, 62 cobalt, 5.5 molybdenum, 1 iron), Type 347 stainless steel (18 chromium, 10 nickel, 0.8 columbium), and 19-9D1 stainless steel (19 chromium, 9 nickel, 2 molybdenum, 1.2 wolfram (tungsten)). After exposure to the vapors for 6 hours, at temperatures of 1350°, 1500°, and 1650°F, a fairly rapid corrosion and a loss of thickness of the uncoated and preoxidized specimens occurred. The ceramic-coated specimens showed no significant attack. The uncoated and preoxidized specimens of Inconel, S-816, and H.S. 21 were more resistant to lead bromide attack than the stainless steels. Photomicrographs.—INCO.

5.4.2, 6.2.3

Ceramic Coatings Prevent Exhaust-Gas Corrosion. D. G. MOORE AND M. A. MASON. Natl. Bur. Standards. *Tech. News Bull., Natl. Bur. Standards*, 35, No. 6, 89-91 (1951) June.

Investigation by the National Bureau of Standards of the corrosive effects of lead bromide vapors on heat-resistant alloys such as Inconel, types 347 and 19-9DL stainless steels, Vitallium, and S-816, both with and without protective ceramic coatings. Lead bromide, principal lead compound in aircraft exhaust gases, was suspected of contributing significantly to exhaust-system corrosion. The test method to determine the loss of thickness of the alloy panels when exposed to lead bromide fumes is outlined and the results are given in table form. The ceramic-coated specimens (NBS types A-417, A-19, and A-520) were unaffected except for slight flaking.—INCO.

5.4.2, 6.3.9, 3.5.9

Study of Chromium-Frit-Type Coatings for High Temperature Protecting of Molybdenum. D. G. MOORE, L. H. BOLZ, I. W. PITTS AND W. N. HARRISON. Natl. Advisory Committee for Aeronautics, Tech. Note 2422, July 1951, 39 pp.

A number of chromium-frit-type coatings (containing 0.01 nickel, copper, aluminum, nickel, tin, titanium, chromium) bonded to molybdenum specimens by firing in controlled atmospheres at 2400-2700°F were studied. Durability of the coatings was determined by oxidation tests under load at 1500°-1800°F and by flame tests at 2000°-3000°F. Results indicate that these coatings may be used at elevated temperatures where long time protection is non-essential or at low temperatures where loading is such that creep rates will be moderate. Photomicrographs.—INCO.

5.4.8, 5.3.4, 1.3

Anti-Corrosive and Decorative Finishes for Metal. A. J. KELLEY. *Hardware J. (Australia)*, 66, No. 1, 56-62 (1951) Jan. 15.

A review of types of corrosion and anti-corrosive finishes. Hot dip galvanized, zinc plated, sherardized and zinc sprayed coatings are described and compared. Chromate passivation treatments are also mentioned.—ZDA.

5.9 Surface Treatment

5.9.1, 5.3.4

Cleaning and Finishing Stainless Steels. T. C. DuMOND. *Materials & Methods Manual No. 69. Materials & Methods*, 33, No. 4, 93-104 (1951) Apr.

Commercial procedures are given for cleaning, pickling, descaling, passivating, grinding, polishing, buffing, plating, coloring, etching, and electropolishing. As with all other processes having to do with stainless steel, cleaning and finishing must be individually tailored to the shop in which the work is done.—INCO.

5.9.2, 5.9.3, 5.4.5

Careful Preparation of the Metal Surface and Application of an Anti-Corrosive are the Bases of Successful Painting. B. BERRUTO. *Ind. della Vernice*, 5, No. 45, 15-17 (1951).

The subject is discussed briefly under the headings: importance of removal of foreign matter; solvent degreasing; mechanical buffing, etc.; treatments; pickling; application of anti-corrosive paint.—RPI

5.9.2, 6.2.5

Taking the "Stain" Off Stainless. *DuPont Mag.*, 45, No. 4, 28-29 (1951) Aug.-Sept.

Sodium hydrite descales stainless steel in 15 sec.-15 min., much faster than by the pickling process. Any size or shape of stainless steel may be treated and there is no metal loss.—INCO.

5.9.2, 6.4.2, 6.2.2

Removal of Aluminum and Iron Coatings. E. LITTELL. *Ind. Finishing (U.S.A.)* 27, No. 7, 106 (1951) May.

Aluminum may be removed from ferrous parts in using a strong solution of caustic soda (NaOH) which will dissolve the aluminum and not attack the ferrous metals. The solution should be hot; the time of the process is directly dependent on the volume of aluminum to be removed. The ferrous parts are then washed in cold water, in clean hot water, and dried. Ferrous iron may be removed from aluminum by the use of a solution of 50/50 nitric acid in water. The aluminum may be slightly attacked by the acid, time and temperature being the controlling factors.—ALL.

5.9.1, 6.4.2, 6.4.4

The Surface Treatment of Aluminum and Magnesium. V. F. HENLEY. *Light Metals (England)*, No. 160, 378-388 (1951) July.

To assist metal finishers who are dealing with light metals for the first time, the author considers the various processes entailed in production and points out the essential differences in technique from those entailed in handling brass, copper or steel. The following steps are covered: (1) Mechanically Produced Finishes—sand and shot blasting, emery finishing, grease mopping, finish polish-



Resin-Bonded Fiberglass®

DUCT-WORK

is

LIGHT, easy to erect

STRONG, needs less support

RESISTANT to many corrosive fumes

ECONOMICAL, made in stock units

VERSATILE, may be custom-molded

AVAILABLE, from new larger plant

ACCEPTED by the chemical industry

PROVED in actual service

Check up on PLA-TANK for new duct jobs now on your drawing-boards - - or for replacements of existing systems.

Write for free data sheet file



65 Waltham Ave., Springfield 9, Mass.

ing, removal of polishing and grinding dust and scratch brushing; (2) Chemical Surface Treatment—acid pickling, alkaline etching, alkaline cleaning, bright dipping, chemically produced surface coatings; (3) Electrochemical Finishes—electropolishing, anodic oxidation and dyeing. Tables are included for the following acid solutions for pickling aluminum alloys, pickling solutions for magnesium alloys, etching solutions, dipping solutions and oxidizing solutions for aluminum alloys, processing schedule for the "Alocrom" process, treatment for giving temporary protection to magnesium alloys, electropolishing treatments for aluminum alloys, typical anodic baths, schedule of replacement finishes for aluminum, sealing reagents and procedures, and the effect of variations in bath and operation.—ALL.

5.9.2, 6.7.3

Painted Galvanized Iron. J. LAWRENCE. *J. Dec. Art.*, 71, Pt. 843, 75-76 (1951).

Weathering is the best treatment that galvanized iron can receive before painting. New galvanized iron may be cleaned with aqueous solutions of alkali cleaners or sulphated detergents and etched with 5 percent copper sulfate or lead acetate solutions. A 3-coat paint system should be applied, based on an elastic primer. Ridges and nailing points should be well covered.—RPI.

5.9.2, 8.8.3, 2.3.6

Cleaning and Preparation of Metals for Electroplating. H. B. LINFORD AND E. B. SAUBESTRE. *Plating*, 38, No. 7, 713-717 (1951) July.

Degreasing evaluation by the atomizer test. This is a new method for determining the presence of greasy materials on a metal surface involving the following steps: 1. evaporation of all surface moisture; 2. spraying of water against panel using an atomizer; 3. measuring of areas covered by thin, uniform film of water.

Details of the equipment and procedure are given. Results obtained with oiled panels which were cleaned to various degrees in alkaline solutions are presented. The theory underlying all wettability tests and differences between the atomizer test and other wettability tests are discussed.—EL.

5.9.3

Brush-Backed Polishing: A New Method of Metal Surface Preparation. *Electroplating*, 4, 117-119 (1951).

A short description of the use and advantages of the brush-backed, coated abrasive-loaded polishing mop in metal finishing.—MA.

5.9.3

Cleaning and Peening with British Hard-Drawn Steel Pellets. *Electroplating*, 4, No. 2, 56 (1951).

The use and advantages of hard-drawn steel pellets for metal cleaning and peening are discussed. A particular advantage of pellets as compared with shot or grit abrasives is that the former can be manufactured in almost all ductile metals and alloys, e.g., stainless-steel pellets are employed for the specialized cleaning of bronze and brass castings, where iron impacted in the surface might lead to objectionable stains during the finishing processes.—MA.

5.9.3, 5.4.1

New Coatings Technology Meets Cor-

rosion Problems. A. J. LIEBMAN. *Chem. Eng. News*, 29, No. 21, 2047 (1951).

Molecular attraction and mechanical bonding combine to form the key between paint and metal surface. The optimum depth of the mechanical bond is considered to be one-third of the thickness of the paint film. Such a bond is produced by sand—or shot-blasting, which also decrease welding and forming stresses. The surface is finally prepared by acid treatment, e.g., with phosphoric acid.—RPI.

5.9.3, 5.9.2

Industrial Polishing of Metals. GERALD F. WEILL. $8\frac{1}{2} \times 5\frac{1}{2}$ in., 194 pp. with 97 illustrations. 1950. London. Iliffe and Sons, Ltd., for Metal Industry. (21s. net; 21s. 8., post free.)

This book is a most welcome addition to the metal-finishing literature and must indeed be one of the very few books in the English language devoted entirely to metal polishing. There is a brief historical survey of the subject, followed by an interesting chapter on the nature of polish and methods of assessing it. Polishing technique and recommended procedures for ferrous and non-ferrous metals are given. A chapter is devoted to polishing compositions, one to polishing wheels, and one to automatic polishing. Barrel polishing receives perhaps less attention than it deserves. Electrolytic polishing is referred to, but only in its broader aspects. There are useful chapters on dust extraction and other polishing-shop problems and on coating. Interesting data are included in a chapter showing the amount of metal removed by polishing. The book is quite well illustrated and is good value for money.—MA.

5.9.3, 8.8.5

Barrel Tumbling: Present Practice in the American Metal Finishing Industry. A. S. KOHLER. *Metal Ind.* (London), 78, Nos. 5 & 9, 88-89, 169-172 (1951) Feb. 2, March 2.

Types, sizes, speeds of various barrels, and auxiliary equipment. Methods employed for shine rolling, deburring, burnishing, together with notes on the media and compounds used.—BNF.

5.9.4, 3.7.3, 6.2.1

Nitriding of Various Kinds of Steel. (In French.) JEAN DAURAT. *Metallurgie*, 83, 255-258, 266, 363-371, 479-481, 483 (1951) Apr., May, June.

Preliminary heat treatment, hardness, and effect of foreign bodies in surface-nitriding processes are described. Properties of nitrided cases for 10 common types of steel are described, as well as properties of nickel, graphite, austenitic steels, and cast-iron. Nitriding of non-oxidizable steels, limitations and advantages are considered. The latter include absence of deformation and increased resistance to heat and corrosion. Nitriding procedure is also discussed. Data are tabulated and charted.—BLR.

5.9.4, 3.8.3

Anodic Polishing and Its Relation to Anodic Passivation. (In German.) KURT HUBER. *Z. Elektrochem.*, 55, 165-169 (1951) Mar.

Reviews literature on the theory and mechanism of the above. 49 references.—BLR.

5.9.4, 5.4.5, 3.7.3

Phosphate Coatings in Defense Pro-

duction. ALFRED DOUTY. *Metal Finishing*, 49, 105-108, 120-121 (1951) July.

Surveys procedures and applications. The latter include: paint-bonding to iron, zinc, cadmium, aluminum, and their common alloys; "rust-proofing" of iron, steel, and aluminum, with or without the aid of corrosion-preventive oils, etc.; protecting friction surfaces of ferrous metal; and improving cold drawing, cold extrusion, and cold forming of steel.—BLR.

5.9.4, 6.2.5

Nitriding Stainless Steels for Better Wear Resistance. SIDNEY LOW. *Steel*, 129, 82, 84, 87 (1951) Aug. 6.

Cycle of 40 hr. at 1000°F, in dissociated and ionized ammonia, following heat treatment, removes oxide layer by nascent hydrogen and is adaptable to conventional furnace equipment.—MR.

5.9.4, 8.9.1

Alodizing Navy Cutlass Fighters Against Corrosion. *Automotive and Aviation Inds.* (U. S. A.), 105, No. 3, 38+ (1951) Aug. 1.

Alodine has been installed along with chromic acid anodizing in the main production finishing line for airplane parts at the new Chance Vought plant at Grand Prairie, Texas. The tank arrangement, which incorporates electrolytic anodizing equipment, consists of the following units: 1) cleaning with Ridoline No. 3192, 2) rinsing with slightly acidified water, 3) chromic acid anodizing, 4) coating with Alodine, 5) rinsing, 6) sealing anodized aluminum, 7) acidulated rinsing (Deoxylite), and 8) drying. At first parts racked in the usual manner for electrolytic treatment showed a considerable number of masked areas after Alodizing, causing rejection of parts. Later tests proved these areas to be lightly but sufficiently coated. A second problem—the difficulty of removing the Alodine coating from rejected parts—was solved by immersing the rejected parts for a short period in the original bath and then rinsing. The coating would then dissolve in nitric acid. Between 90 and 95 percent of parts are treated in this manner. Minor changes have been made in the process since it was incorporated. Metalite, a high strength aluminum-balsa wood sandwich material, is used in 25 percent of the exterior surface of the plane.—ALL.

5.9.5, 5.9.3

Industrial Uses of Ultrasonics. G. E. HENRY. *Gen. Elec. Rev.*, 54, No. 3, 32-35 (1951) March.

Includes a section on industrial cleaning of small metal parts. The action of both alkaline cleaners and hydrocarbon solvents is rendered more effective and speedier if the liquid is irradiated with high-energy sound during the cleaning process; an explanation based on cavitation is advanced. Equipment is described. The removal of buffing compounds by ultrasonics is mentioned. Also tinning of aluminum by soft solder, without use of flux.—BNF.

5.11 Design—Influence on Corrosion

5.11

Recommended Design Details to Reduce Corrosion. *Product Eng.*, 22, No. 7, 158-159 (1951) July.

Diagrams are briefly explained.—BLR.

5.11, 3.6.5

Electro-

DURKIN.

Feb.

Discus-

tance as

materials

vide a no-

will not

tion; but

knowledge

produce c

5.11, 5.1

Corros-

turing E

World E

584 (195

No. 5, 11

The au-

thority by

methods

must be

article, s

table for

methods

right me

ess woul

tection n

—RPI.

6. MA

CO

6.1 Ge

6.1, 4.3.2

Materi-

to Chrom

147+ (1

A seri

chromic

construct

1) "H

2) "C

3) "I

4) "S

5) "C

6) "R

7) "T

8) "N

9) "C

10) "L

11) "C

12) "D

13) "C

14) "A

15) "V

16) "C

17) "S

18) "V

6.1, 4.3.2

Corros-

rosion E

Trifluor

AND K.

Research

Supply

Applied

(1951) A

The d

a very l

with it

stability

common

particul

Boron

active ga

of moistu

and hydr

5.11, 3.6.5

Electrolytic Corrosion of Metals. A. E. DURKIN. *Gen. Elec. Rev.*, **54**, 45-48 (1951) Feb.

Discusses the above and its importance as a design factor in selection of materials. The electromotive series provide a guide in choosing materials that will not give rise to electrolytic corrosion; it must be supplemented by knowledge of conditions which may introduce exceptions. 12 references.—BLR.

5.11, 5.1

Corrosion Prevention in the Manufacturing Process. J. R. FAWCETT. *Mech. World Eng. Record*, **129**, No. 3354, 381-384 (1951) Apr. 27; *Rail Eng. Abs.*, **6**, No. 5, 117-118 (1951).

The amount of iron and steel lost annually by corrosion is a reflection on the methods of protection used. Protection must be begun at the design state of an article, so that when produced it is suitable for the application of protective methods to it. The incorporation of the right method in the manufacturing process would then follow. The various protection measures available are discussed.—RPI.

6. MATERIALS OF CONSTRUCTION

6.1 General

6.1, 4.3.2

Materials of Construction: Resistance to Chromic Acid. *Chem. Eng.*, **58**, No. 2, 147+ (1951) Feb.

A series of articles on the effect of chromic acid on various materials of construction include:

- 1) "High-Silicon Irons," W. A. Luce;
- 2) "Coatings," K. Tator;
- 3) "Iron and Steel," A. W. Spitz;
- 4) "Stainless," G. L. Snair;
- 5) "Glass Linings," S. W. McCann;
- 6) "Rubber Linings," J. P. McNamee;
- 7) "Tantalum," L. R. Scribner;
- 8) "Nickel and Alloys," W. Z. Friend;
- 9) "Carbon," W. M. Gaylord;
- 10) "Lead," K. H. Roll;
- 11) "Chemical Stoneware," F. E. Herstein;
- 12) "Durimet 20," W. A. Luce;
- 13) "Chlorimets," W. A. Luce;
- 14) "Aluminum," A. B. McKee & A. Fitz;
- 15) "Wood," H. B. Smith, III;
- 16) "Cements," R. B. Seymour;
- 17) "Silicones," J. A. McHard & L. V. Volkinberg;
- 18) "Worthite," W. E. Pratt.

6.1, 4.3.2

Corrosion by Boron Trifluoride. Corrosion Experiments with Gaseous Boron Trifluoride. F. HUDSWELL, J. S. NAIRN and K. L. WILKINSON, Atomic Energy Research Establishment, Ministry of Supply, Harwell, Berks, England, *J. Applied Chem. (London)*, **1**, 333-336 (1951) Aug.

The demand for boron trifluoride of a very high degree of purity brought with it the necessity to investigate the stability to this gas of those materials commonly used in neutron counters in particular, and in chemical plant in general.

Boron trifluoride, an extremely reactive gas, is rapidly attacked by traces of moisture to give hydroxyfluoric acids and hydrogen fluoride as products of the

reaction. Hence boron trifluoride of the very highest purity was used throughout in the experiments described in this report.

The following materials can be safely used in apparatus for handling dry boron trifluoride: Stainless steel, mild steel, copper, nickel, Monel Metal, brass and aluminum, the more noble metals up to at least 200°C; Pyrex glass is also suitable up to about 200°C. Araldite cement, fired pyrophyllite and polytetrafluoroethylene may be used. A number of other miscellaneous compounds tested, including some plastic materials, were quite unsuitable for use with boron trifluoride.

6.1, 4.3.6

Materials of Construction Versus Ferric Chloride. *Chem. Eng.*, **58**, No. 5, 244+ (1951) May.

Papers include:

- 1) "Stainless Steel" G. L. Snair, Jr.;
- 2) "Worthite," W. E. Pratt;
- 3) "Nickel and Nickel Alloys," W. Z. Friend (Inco);
- 4) "Rubber Lining," J. P. McNamee;
- 5) "Cements," R. B. Seymour;
- 6) "Aluminum," E. D. Verink, Jr.;
- 7) "High-Silicon Irons," W. A. Luce;
- 8) "Durimet 20," W. A. Luce;
- 9) "Carbon and Graphite," R. O. Joslyn;
- 10) "Chlorimets," W. A. Luce;
- 11) "Glass Lining," S. W. McCann;
- 12) "Hastelloy," E. D. Weisert;
- 13) "Wood," H. B. Smith, III;
- 14) "Coatings," K. Tator;
- 15) "Tantalum," L. R. Scribner;
- 16) "Silicones," J. A. McHard & J. T. McIntyre.—INCO.

6.1, 4.3.6

Materials of Construction for Copper Sulphate. *Chem. Eng.*, **58**, No. 4, 206+ (1951) Apr.

Among the materials of construction discussed are:

- 1) "Carbon," W. W. Palmquist;
- 2) "High-Silicon Irons," W. A. Luce;
- 3) "Worthite," W. E. Pratt;
- 4) "Nickel and Nickel Alloys," W. Z. Friend (Inco);
- 5) "Glass Lining," S. W. McCann;
- 6) "Stainless Steel," G. L. Snair, Jr.;
- 7) "Durimet 20," W. A. Luce;
- 8) "Chlorimets," W. A. Luce;
- 9) "Silicones," J. A. McHard & J. T. McIntyre;
- 10) "Aluminum," E. D. Verink, Jr.;
- 11) "Coatings," F. Tator;
- 12) "Rubber Lining," J. P. McNamee;
- 13) "Wood," H. B. Smith, III;
- 14) "Cements," R. B. Seymour;
- 15) "Tantalum," L. R. Scribner;
- 16) "Iron and Steel," A. W. Spitz;
- 17) "Lead," K. H. Roll;
- 18) "Hastelloy," E. D. Weisert.—INCO.

7. EQUIPMENT

7.2 Valves, Pipes and Meters

7.2, 6.2.2

Corrosion Resistance of Wrought Iron and Steel Pipe. S. L. CASE, Battelle Memorial Inst. *Metal Progress*, **59**, No. 3, 378-384 (1951) Mar.

Survey of technical data indicates that wrought iron and steel do not differ materially in their behavior under corrosive conditions in the soil, concrete, and other environments surrounding



"PUTTING
PERMANENCE
IN PIPE"

CLEANING, COATING, WRAPPING & RECONDITIONING

★
HOT DOPE
Straight from the Kettle
on PIPE PROTECTION

★
By Boyd Mayes

● A friend called up recently to learn why we'd missed out on several miles of big-inch that was going down almost under our nose. We told him we'd made an honest bid on the job, figured on a fair and reasonable profit, but had lost to a bid that couldn't, even by slight-of-hand performance, do more than break even on the job. He asked why we didn't underbid the cost and chunk in enough "extras" to make our profit. We've got a stock answer for that one: In more than a quarter of a century of doing a creditable job for the pipe line industry we've followed the same old policy: "We refuse to laugh our way into a job, then cry our way out!"

MAYES BROS.

1150
McCarty

HOUSTON, TEXAS

OF CARD
7546

radiant heating panels. Differences in corrosion resistance of various wrought irons are often greater than between steel and wrought iron. In highly corrosive soils the service life of either is very short. In other environments, either one or the other may prove somewhat superior, but claims of consistent superiority are not supported by facts. Tables giving corrosion data in the atmosphere, in various soils, upon exposure to hot water and steam, and in concrete are included. Corrosion of samples was measured by the loss in weight and by the depth of the pitting.—INCO.

7.2, 6.2.5

Stainless Pipe. *Chem. Eng.*, 58, No. 8, 144 (1951) Aug.

Stainless steel tubing in sizes corresponding to standard pipe for the outside diameters but in wall thicknesses corresponding to Schedule 5 is being produced. Its larger inside diameter provides increased fluid handling capacity. Where high working pressures are encountered Schedule 40 or heavier is recommended. Corrosion resistance of Schedule 5 is the same as that of other products made from the same alloys. Manufactured by Carpenter Steel Co.—INCO.

7.2, 6.2.5, 2.2.4

Nickel-Chromium-Molybdenum Steel Valve Casting After 50,000 Hours of Service at 900° F. T. N. ARMSTRONG AND R. J. GREENE. *Trans. Am. Soc. Mech. Engrs.*, 73, 751-754 (1951) Aug.

Describes tests made on above. Results indicate that there was no loss of strength, no embrittlement, and no formation of graphite in the valve. Photomicrographs given.—BLR.

7.2, 6.3.6

Copper Water Pipes. *Water and Water Eng. (Gt. Br.)*, 53, 124 (1950) Mar.

British Non-Ferrous Metals Research Assoc. has for several years been studying behavior of copper in supply waters with particular reference to pitting type of corrosion which occurs occasionally in certain districts, particularly in cold-water pipes. As a result, the Assn. now states: (1) No evidence to establish superior corrosion resistance of either of 2 grades of copper allowed by British standards. Phosphorus-deoxidized non-arsenical copper (B.S. 1172: '44) equally satisfactory. (2) Pitting corrosion of copper cold-water pipes usually due to carbonaceous films produced inside tubes by some mfg. conditions. (3) Pitting corrosion does not occur in majority of supply waters even if carbonaceous films present. (4) No evidence concerning effect of carbonaceous films on serviceability of hot-water pipes. Two types of corrosion of copper water pipes observed are "green staining" and "pitting." Former experienced with waters containing high proportion of carbon dioxide. Hot-water pitting seems to be confined to soft moorland waters, whereas cold-water pitting mainly confined to hard borehole waters, although its incidence bears no apparent relationship to usual water anal. Close correlation found between carbon present in carbonaceous film and pitting in cold water. Both carbonaceous films and oxide scales lead to pitting in cold waters, which do not contain inhibitor, by providing large cathodic areas that localize attack at pores in film or scale. Ample evidence that copper water pipes free from such carbonaceous film and oxide scales are satisfactory even in uninhibited waters—AWWA.

7.3 Pumps, Compressors, Propellers, Impellers

7.3, 1.3, 8.8.1

Centrifugal Pumps in the Chemical Industry. J. GAHUS. *Chimie et Industrie*, 65, No. 5, 657-664 (1951).

A review of the many and varied uses to which the centrifugal pump has been put in the handling of corrosive liquids in the industrial chemical field, with particular emphasis on its versatility and on variations in design.—EL.

7.3, 6.2.5, 6.3.6

Centrifugal Pumps—Construction Materials—I & II. I. J. KARASSIK AND R. CARTER. (Worthington Pump & Mach. Corp.) *Paper Ind. and Paper World*, 33, Nos. 3, 4, 297-298, 411-412 (1951) June-July.

Part I. General picture of the factors to be considered in the evaluation of material for use in centrifugal pump parts. Construction materials for pump components, pump fittings, salt water pumps, limitations on cast iron for pump casings and limitations on bronze for pump fittings are discussed. Centrifugal pump casings are usually made of cast iron. Bronze is used for casings when the liquid is mildly corrosive, such as, sea water. Stainless steel casings are used when the pumped liquid is corrosive or excessively abrasive. Bronze impellers are generally preferred when handling average waters. When the liquid handled is a strong electrolyte, regular or alloy cast iron, cast steel or stainless steel impellers may be used. Bronze impellers are seldom used when the liquid temperature exceeds 250-270° F. Wearing rings are usually made of bronze but cast iron, cast steel, stainless steel or Monel rings are sometimes used. In pumps where shaft sleeves are used, shafts are generally made of open hearth steel. Shafts of pumps made without shaft sleeves are made of stainless steel, phosphor bronze or Monel metal. Shaft sleeves are made of bronze. When high abrasion resistance is required, they are made of stainless steel. Glands are generally made of bronze. An all bronze pump should give the longest life for sea water conditions. In pumps handling liquids (such as brine) at very low temperatures, pump casings are made of alloyed cast iron or cast steel.—INCO.

Part II. The rate of corrosion of pump parts is affected by the pH of the liquid being pumped. Standard bronze fitted pumps should not be used for pH values below 6.00 or above 8.5 at the pumping temperature. Below 6.00, all bronze pumps or stainless steel fitted pumps should be used, while above 8.5, the pumps should be cast iron or stainless steel fitted. The effect of structural features, of load factor, and of metallurgical advances on the selection of pump materials is discussed. The temperatures and pH at which cast iron, C steel, and stainless steel casings, and bronze or stainless steel fittings may be used for boiler feed pumps are given in chart form.—INCO.

7.5 Containers

7.5.5

Organic Tank Linings: An Outline of Care and Maintenance. MANSON GLOVER AND GUNNAR LINDH. *Plating*, 38, No. 5, 471-472 (1951).

General information is presented on

tanks suitable for lining, tank installation, on means of preventing damage by heat or mechanical causes, and on controlling corrosion.—MA.

7.5.2, 5.3.2

Certain Aspects of Internal Corrosion in Tin Plate Containers. R. R. HARTWELL. "Advances in Food Research, Vol. III." Academic Press, New York, 1951, p. 327-383. (TX537 A93.)

Comprehensive descriptive review covers manufacture of tinplate, mechanism of corrosion, corrosion characteristics of foods, and their components, effects of the trace elements sulfur and copper, effects of weight and porosity of the tin coating, effects of the steel base, tinplating testing, enameled cans, and electrolytic tinplate. 142 references.—BLR.

7.5.5, 5.10

How to Prevent Corrosion of Tank Bottoms. *Petroleum Refiner*, 30, No. 2, 89 (1951) Feb.

Method in use to eliminate the corrosion from the effects of soil conditions. A 6-inch bed of compacted gravel, kept from spreading by a steel retaining wall, is used to elevate the bottom of the tank. The retaining wall is made of short sections of steel plate bolted together, and has a diameter of about 1 foot more than the tank. To prevent buckling or raising, the wall is also bolted to steel rods driven into the ground at intervals around the circumference of the wall. The gravel bed prevents contact of the tank bottom with soil, eliminating corrosion and providing a dry support.—INCO.

7.6 Unit Process Equipment

7.6.1, 6.1, 3.1

Problems of Material in the Design of Chemical Equipment. L. PIATT. *Schweiz. Arch. angew. Wiss. u. Tech.*, 11, 80-91 (1951) Mar.

The failures and successes of steels in high temperature, high pressure reactions in the presence of hydrogen are discussed. Included are: corrosion from galvanic, stray, and local currents, and from microorganisms; contact, intercrystalline, transcrystalline, and fatigue corrosion; caustic brittleness, frictional oxidation, cavitation wear, high temperature corrosion. Ways of minimizing these effects are indicated.

7.6.4, 5.3.2

Prevention of Slagging and Corrosion by Means of Protective Coatings on the Fire Side of Boiler Heating Surfaces. (In German.) H. BOHME. *Brennstoffe Wärme-Kraft*, 3, 189-192 (1951) June.

Reports effects of treatment of the boiler-tube surfaces with lime and with graphite, and of coating them with different metals. Photographs and tabular data show that only the graphite-treatment gives satisfactory results.—BLR.

7.6.4, 5.8.4, 5.9.2

Anti-Corrosive for Boilers and Metal Heating, Piping & Air Conditioning. No. 7, 201 (1951) July.

"Corrosanti," an anti-corrosive for boiler and metal protection comes in four grades. One grade, which seals the pores in boiler metal surfaces, removes scale deposits and prevents rust, pitting, and corrosion. Another grade is a rust inhibitor for ferrous metals subject to



Above ground—Polyken Protective Tape Coatings have a high resistance to aging and are inert to atmospheric attack.

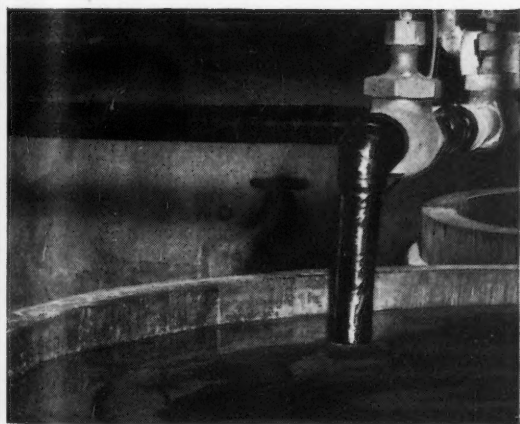


Under ground—where protection is needed against electrolytic and chemical attack, Polyken Protective Tape Coatings provide excellent resistance and high dielectric strength. These coatings are resistant to bacterial and fungus attack.

Field-tested Polyken Protective Coatings

fight corrosion

• ATMOSPHERIC • CHEMICAL • ELECTROLYTIC



Even direct chemical attack at normal operating temperatures, is resisted by Polyken elastic, calendared polyethylene Tape Coatings.

Above and under the ground, the new Polyken Polyethylene protective Tape Coatings in field tests have successfully combated atmospheric, chemical and electrolytic corrosion on pipe surfaces. This superior protection is so quickly and easily applied that even an inexperienced workman can now wrap pipe uniformly by hand or machine.

The tough 8 mil plastic backing of this Polyken Tape Coating provides all the well-known protective advantages of polyethylene—extremely low moisture vapor transmission rate, high dielectric strength, and excellent resistance to aging, chemicals, bacteria and electrolytic action. To these advantages, Polyken adds the extra protection of a 4 mil adhesive mass—a stable protective barrier in itself—that provides a superior bond to all metal surfaces, a better penetration of surface voids, and an excellent bonding adhesion on overlaps.

This Polyken Protective Tape Coating is available in two colors: No. 900, black and No. 910, aluminum gray.

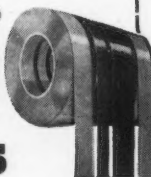
See how Polyken Protective Tape Coatings can solve your corrosion problems. Test samples and further information are available now.

TAILORED TO YOUR JOB

Polyken®

INDUSTRIAL TAPES

Department of Bauer & Black
Division of The Kendall Company



Polyken, Dept. CB
222 West Adams St., Chicago 6, Illinois

Please send me samples and further information on
POLYKEN PROTECTIVE TAPE COATINGS.

Name _____ Title _____

Company _____

Street Address _____

City _____ Zone _____ State _____

water and water vapor, and a third protects metal surfaces exposed to acid and other corrosive vapors, gases, acid forming conditions, brines, etc. The fourth is designed for ferrous surfaces, as boiler fronts, subjected to temperatures up to 900° F.—INCO.

8. INDUSTRIES

8.4 Group 4

8.4.3, 2.3.6

Corrosion-Prevention in a TCC Gas Plant. C. A. MURRAY AND M. A. FURTH. *Petroleum Engineer*, 23, C3, C5-C8 (1951) July 15.

Corrosion-control measures for the gas plant of a modern catalytic-cracking unit at Pure Oil Company's refinery in Nederland, Texas. Inspection and laboratory data were used to assess the degree and nature of corrosion. No matter where corrosion occurred, it was found to be almost entirely associated with excessive water present in the system. A corrosion-control program was put into effect that consisted, for the most part, of water-removal measures at key points.—MR.

8.4.3, 6.2.3

Analyses of Some Corrosion Problems in Petroleum Refineries. J. F. MASON, JR. The International Nickel Co. *Petroleum Refiner*, 30, 124 (1951) Oct.

Presented in this article are 15 case records of actual corrosion problems. The problems concern the initial use of carbon steel for the various equipment items and premature failure for one reason or another. Among the services involved are gas oil, spent sulphuric acid alkylate, depropanized naphtha, crude oil, naphthenic base crudes, caustic soda and soda plumbite, furfural, reduced crude vapors and cracked propane distillate.

8.4.3, 6.6.8

The Selection of Treating Processes for Gasoline Plants. G. M. BROONER. Phillips Petroleum Co. Paper before Natural Gasoline Assoc. of Am., Permian Basin Regional Mtg., Big Spring, Tex., Feb. 23, 1951. *Petroleum Refiner*, 30, No. 4, 95-99 (1951) Apr.

Review of the better known operations and their applications. One of the problems attendant with the increase in moisture content of the reagent is corrosion of the treating vessel itself. Where corrosion is a really critical item in the operation of the units, it was found that lining the vessel with Saran gives perfect protection. Saran is a synthetic resin that is completely resistant to the corrosive action of copper.—INCO.

8.4.3, 7.4.2

Corrosion-Prevention Program for T.C.C. Gas Plant at its Smiths Bluff Refinery. C. A. MURRAY AND M. A. FURTH. *Oil and Gas Journal*, 50, 112, 115-116+ (1951) May 24.

Failures and replacements necessary in tubular heat-exchange equipment. Prevention measures and benefits to date of the program.—MR.

8.5 Group 5

8.5.3

Corrosion and Field Lining of Sulphate Digesters. T. T. COLLINS, JR., S. J. BAISCH, AND G. T. VANDER VELDEN. *Paper*

Trade Journal, 132, 24+, 18+ (1951) Feb. 9, 16.

Discusses above problems and describes experiences of Thilmany Pulp & Paper Co., Kaukauna, Wis. Illustrated.—BLR.

8.5.3, 7.6.6, 5.8.2

The Effect of Silicates on Digester Corrosion. J. C. HAIR, Production Manager, and A. W. DUSKIN, Technical Service Director, Crossett Paper Mills, *Tappi*, 34, No. 6, 252 (1951) June.

In an attempt to decrease the corrosion rate in its pulp digesters, the paper mills added sodium silicate and high-silica clays to the liquor system with the anticipation that a protective scale would be formed in the digesters and corrosion thereby inhibited. At the conclusion of a 9-month test, there had been no formation of a high-silica protective scale, nor had there been any reduction in the corrosion rate.—NALCO.

8.8 Group 8

8.8.1, 6.2.1, 6.3.1

Construction Materials for the Chemical Industry. Part I. Iron and Steel. Part II. Nonferrous Metals. (In German.) E. FRANKE. *Werkstoffe u. Korrosion*, 2, 173-181, 249-258 (1951) May, July.

Surveys corrosion of stainless steels, austenitic magnesium steels, iron alloys with a high content of silicon, heat resisting low-alloyed steels, carbon steels, and cast iron, as well as their possibilities for use in the chemical industry. Part II discusses copper, aluminum, nickel, titanium, zirconium, tantalum, and the noble metals. Reviews the literature. 255 references.—MR.

8.8.1, 6.1

Fluoride Scrubbers. A. B. PETTIT. Paper before Air Pollution & Smoke Prevention Assoc. of America, Roanoke, May 8, 1951. *Chem. Eng.*, 58, No. 8, 250, 252 (1951) Aug.

In the production of superphosphate, the silicon fluoride (SiF₄) water spray scrubbing tower has spray nozzles of Monel or stainless steel. The fan has a cast steel spider, plywood blades, and Monel bolts.—INCO.

8.8.5, 5.4.8, 5.3.2

Metal Coloring, Methods of Treatment for Iron and Steel Smallware. C. HARRIS. *Metal Ind.* (London), 78, No. 8, 143-146 (1951) Feb. 23.

Methods of treatment of iron and steel smallware, giving various formulae used in this field of metal coloring. The processes for temper and black colors, chemical blacks, phosphate coatings and protective coatings by hot tinning, hot galvanizing and sherardizing are discussed.—INCO.

8.9 Group 9

8.9.2, 2.3.2, 4.6.3

Do Salts Used for Ice Control Speed Rusting of Automobiles? *Eng. News-Record*, 146, No. 20, 39-41 (1951) May 17.

Disagreement evident among public officials who studied the question points to the need for a more comprehensive study. The study made by Inco of the

effect of salt in accelerating corrosion is reviewed. Another study by the Testing and Research Div. of the Michigan Highway Department found no significant difference in the corrosive effects of sodium chloride or calcium chloride solutions. It did confirm, however, Inco's findings as to the severe effect of weak solutions. Studies at Akron show that chromates would definitely reduce salt corrosion also that chromates arrest the corrosion at the body and fender joints that continues throughout the summer everytime the car becomes wet. In a report made in 1949 to the Am. Public Works Assn., it is stated concerning the results of the salt and fresh water spray tests reported by Inco, that those laboratory findings are not supported by actual experience. Automobiles driven in cities where de-icing salt is used rust much more rapidly than those not exposed to salt.—INCO.

8.9.3, 2.3.5

Measurements of Line Currents. M. E. PARKER. *Oil Gas J.*, 50, No. 17, 89 (1951) Aug. 30.

A technique used in studying corrosion on a pipe line is the measurement of currents flowing along the line. It is necessary to use a section of the pipe as a shunt or to determine the current by measuring the voltage drop of a high-resistance voltmeter or a potentiometer is used.—INCO.

8.9.3, 3.6.6

Interconnection of Pipe Lines Having Various Coatings. DAVID HENDRICKSON. Paper, Seventh Annual Conference, Natl. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 6, No. 6, 212-216 (1952) June.

This article deals with the design of concrete coated steel aqueducts interconnected with aqueduct with bituminous coating. The galvanic current generated by interconnecting the two aqueducts with different coatings is shown in a specific case. The proper method for isolating these aqueducts is discussed as well as the results of trying to isolate the two pipe lines by installing insulating joints within a network of interconnecting pipes. Test data are given on forced drainage on these incorrectly placed insulating joints in order to reverse residual galvanic currents in the pipe network. The reason operating experience should not overrule recommendations based on electrolysis investigation is given. The AC method, developed for locating accidental short circuits in control piping, conduits and other metallic connection is given. A comparison based on soil resistivity is made between the Mokelumne Aqueducts and the Hetch Hetchy Aqueducts in galvanic currents generated by interconnection. Precautions in the form of a soil survey were taken by the Hetch Hetchy engineers. Insulating joints were installed in their first aqueduct at strategic points. Test data are given on these insulated joints after 17 years of service. Good results obtained by following recommendations based on electrolysis surveys for the pipe coating have been well justified. Accidental short circuit between the two Hetch Hetchy Aqueducts at the San Joaquin Valve House was discovered by the preliminary electrolysis survey after the installation of the Second Aqueduct. The misconception of some engineers that a welding machine grounded to one aqueduct may be used just as effectively on the adjacent aqueduct has resulted in much disregard for recom-

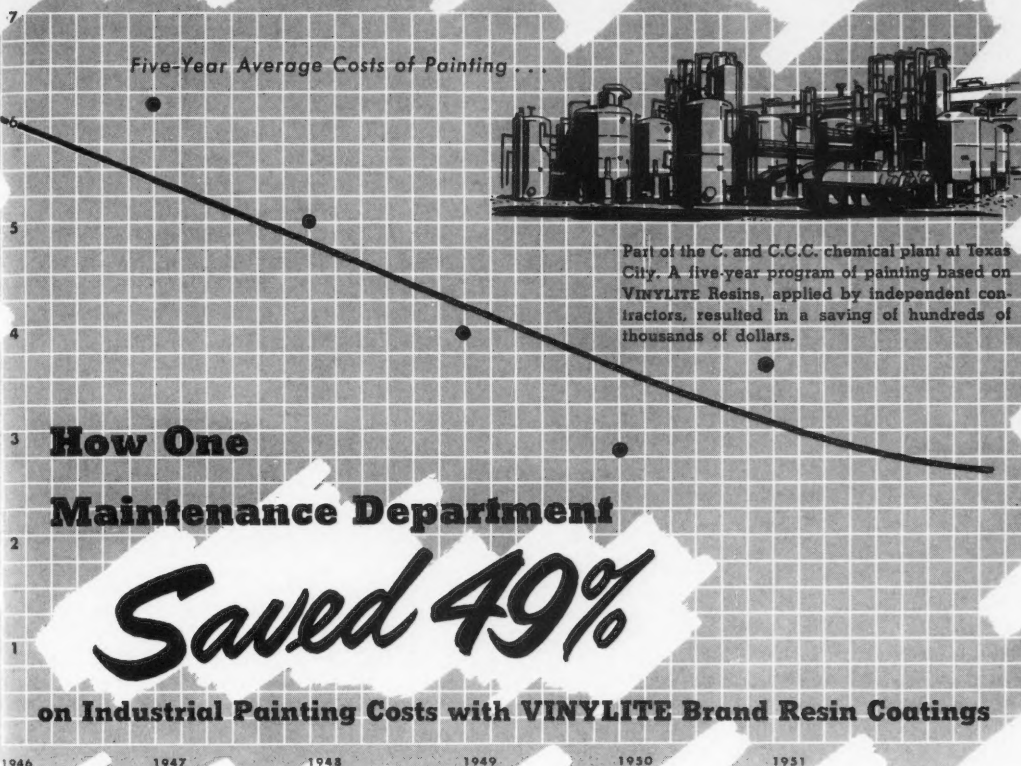
osion is
Testing
Michigan
signifi-
effects
chloride
Inco's
f weak
w that
ce salt
est the
r joints
summer
In a
Public
ing the
r spray
se lab-
ted by
driven
ed rust
not ex-

nts. M.
17, 89

corro-
urement
ne. It is
pipe as
rent by
a high-
ometer

Having
RICKSON
ce, Natl.
York
osion, &

esign of
s inter-
uminous
generated
educts
yn in a
hod for
assed as
isolate
insulate
of inter-
given on
correctly
r to re-
in the
ting ex-
menda-
tigation
opped for
in com-
metallic
on based
reen the
e Hetch
currents
Precar-
ey were
engineers
in their
ts. Test
ed joints
results
ndations
the pipe
d. Acci-
the two
the San
scovered
survey
Second
some en-
grounded
just as
duct has
recom-



Here is a saving of hundreds of thousands of dollars graphically shown on a chemical company's actual cost chart plotted over a five-year period. Painting costs have decreased steadily every year since VINYLITE Resin coatings, applied by experienced independent contractors, were adopted. The report of a special study reads in part:

"Use of VINYLITE resin based paint and outside paint contractors has reduced the painting costs on an equivalent basis by 49 per cent since 1946-1947. Use of VINYLITE Resin wash primers and paint on new construction should eventually reduce costs even further."

The toughness and long life of these VINYLITE Resin coatings bring outstanding results for chemical plants, oil refineries, pipelines, dairies, tank cars, marine equipment . . . wherever surfaces are exposed to rough treatment, chemicals, salt water, weather extremes, industrial fumes.

Properly applied, by spray dip or brush, finishes based on VINYLITE Resins won't crack, chip, peel, or fade. They stay put on metal, concrete, masonry. For most practical purposes, they're inert, odorless, tasteless. They come in any color.

These same qualities make VINYLITE Resin coatings ideal for protecting packages and food containers against package deterioration and contamination.

Whatever your plant or product . . . inside or out, you can improve performance as well as cut costs by using coatings based on one of the many BAKELITE or VINYLITE Resins. Your coating supplier has formulations for specialized uses based on BAKELITE phenolic, vinyl chloride acetate and polystyrene resins.

Get the facts now. Write Dept. OS-69 for folder telling more about this case and other case histories of finishes exposed to chemicals.

Vinylite
BRAND
RESINS

TRADE MARK
BAKELITE COMPANY

A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N.Y.



Interior wall paints based on BAKELITE Polystyrene Emulsion dry rapidly — yet brush well. Washable, the even coating shows no lapping or brush marks.



Uncoated heat-exchanger tube lasted four months. Lower tube, coated with BAKELITE Phenolic Resin baking finishes, was practically unaffected after eleven months.



Contact with corrosive soda ash for fifteen months failed to damage this hopper car's tough, tenacious coating based on VINYLITE Brand Resins.

INDEX TO ADVERTISERS

Vol. 9 FEBRUARY, 1953 No. 2

	Page
Amercoat Corporation	Inside Front Cover
American Cast Iron Pipe Co.	20
American Chemical Paint Co.	41
Bakelite Company, Union Carbide & Carbon Corp.	65
Bechtel Corp. & H. C. Price Co.	x
Brance-Kracy Co., Inc.	21
Calgon, Incorporated	xii
Carpenter Alloy Tube Div.	31
Cathodic Protection Service	17
Chemical Corporation	59
Coast Paint & Lacquer Co.	ii
Cooper Alloy Foundry, Inc.	15
Corrosion Directory	52, 53
Dresser Industries, Inc.	35
Duriron Co., Inc.	Inside Back Cover
Eastman Chemical Products, Inc.	39
Federated Metals Division, American Smelting & Ref. Co.	9
Harper, H. M. Company	8
Haynes Stellite Company, Division Union Carbide & Carbon Corp.	21
Hercules Powder Company	25
International Nickel Co., Inc.	vi, 29
Johns-Manville Sales Corp.	11
Koppers Company	xiii, 49
LaFavorite Rubber Co.	46
Mayes Bros., Inc.	61
Michigan Pipe Company	43
Middle West Coating & Supply	48
Miller, Ray, Inc.	45
Minnesota Mining & Mfg. Co.	19
Monsanto Chemical Co.	12
National Association of Corrosion Engineers	ix, 56
National Carbon Company, Union Carbide & Carbon Corp.	xi
Nelson Electric Mfg. Co.	32
Nicolet Industries, Inc.	51
Owens-Corning Fiberglas Corp.	vii
Pipe Line Service Corporation	ix
Pipeline Anode Corporation	33
Pittsburgh Coke & Chemical Co.	i
Plastic Engineering & Sales Corp.	54
Polyken Industrial Tapes, Dept. of Bauer & Black	63
Positions Available & Wanted	53
Reilly Tar & Chemical Corp.	5
Richardson-Allen Corp.	55
Royston Laboratories, Inc.	47
Saran Lined Pipe Co.	44
Service Engineers, Inc.	22
Stearns, D. E. Company	Back Cover
Tapecoat Company, The	40
Tretolite Company	37
United Chromium, Inc.	7
United States Stoneware Company	16
Van Dorn Iron Works Company, The	30
Williamson, T. D., Inc.	23

mentations by the electrolysis engineer. Recommended precautions set forth.

8.9.3, 5.1

Corrosion Program for a Pipe Line. M. E. PARKER. *Petroleum Eng.*, 23, No. 5, D68, 70, 72, 74, 76-80 (1951) May.

Procedures for planning, designing and installing a corrosion-protection system for pipe lines to obtain maximum efficiency at minimum cost are recommended.

8.9.3, 5.1

Corrosion Control for a New Gas Transmission Line. C. MCGRAW. Paper, Am. Gas. Assoc. Conference, Memphis, Apr. 16-18, 1951. *Pipe Line News*, 23, No. 6, 6A-7A (1951) June.

Most satisfactory pipe line corrosion control is obtained by instituting in the early stages of construction a planned program including protective coating and cathodic protection.

8.9.3, 5.4.5

United Coats 150 Miles of Line in South Louisiana. *Oil Gas J.*, 50, No. 7, 274, 276 (1951) June 21.

Somastic coating is used to withstand severe corrosive attacks on gas pipe line in the marshlands of southern Louisiana. A thick sleeve of hot (400° F.) asphalt mastic is applied to the outside of the pipe and the pipe is then coated with whitewash to speed cooling. The joints are dried and cleaned before coating by a grit blasting machine with steel shot. The joints are welded in the field and then coated.—INCO.

8.9.3, 6.4.2, 7.2

Light Weight Pipelines: Aluminum Has Come of Age. Part II. W. B. MOORE. *The Oil Forum (U.S.A.)*, 5, No. 5, 162-163 (1951) May.

During extension of the natural gas distribution system of Alabama-Tennessee Natural Gas Co., to the Listerhill, Ala., plant of Reynolds Metals Co., a 1.8 mile section of 8½-inch OD aluminum pipe was incorporated with the steel line. Comparative data were compiled and the details are given in two tables. Nine advantages of aluminum pipeline are stated.—ALL.

8.9.4

Rail Corrosion in the Moffat Tunnel. WALTER LEAF. *Corrosion (New Section)*, 7, No. 5, 1 (1951) May.

Briefly describes the above and methods being tested to minimize the corrosion of rail, tie plates, and spikes.—BLR.

8.9.4, 1.7.1

Investigation of Failures in Railroad Rails. R. E. CRAMER. *Bull. Am. Ry. Eng. Assoc.*, 52, 605-617 (1951) Feb.

Part of Report on Assignment 2, "Conditions Affecting Service Life of Rail, Causes of Rail Failures and Other Defects," from report of Committee 4 on Rail. 23 failed control-cooled rails from 16 railroads were subjected to laboratory examination. Distribution of fracture types and causes is tabulated. Fabrication procedures at Algoma steel mill were investigated in order to clarify causes of failures. Includes micrographs and micrographs.—BLR.

8.9.4, 6.2.4, 5.11

Corrosion of Railroad Hopper Car Body Sheets. B. J. KELLY. U. S. Steel Co. Paper, 7th Ann. Conf., Natl. Assoc. Corrosion Engrs., New York, March 13-16, 1951. *Corrosion*, 7, No. 6, 196-201 (1951) June.

The corrosion of railroad hopper car body sheets is dependent upon the character of the lading, the atmospheric conditions to which the car is subjected, the design of the car, and the composition of the body sheets. Information obtained from a large number of tests of various materials exposed in different kinds of atmospheres has been correlated with data obtained from service tests of a few of these materials in railroad hopper cars. On the basis of assigned ratings of 1 for carbon steel, it has been found that copper steel has an atmospheric corrosion resistance rating of 2 and a performance rating of 1½ to 1½ in general service. A carbon-manganese-copper-steel which also has an atmospheric corrosion resistance rating of 2 and a strength level somewhat higher than that of copper steel, is slightly superior to copper steel in hopper car service. The service performance of a high strength steel which has an atmospheric corrosion resistance rating of 5+ and a strength level equal to that of the carbon-manganese-copper-steel, is considerably better than that of copper steel. Examination of hopper car bodies constructed of carbon steel, copper steel and high strength steels has shown that failures in the sheets generally occur in areas where lap joints or ledges permit accumulation of moisture, dirt and fines, and in areas adjacent to stiffening members. The results of these investigations indicate that in order to obtain the maximum service from materials used for hopper car bodies, the design of the car must be considered simultaneously with the composition of the sheet material.

8.9.5, 7.5.5

Corrosion of Oil Tanks. *The Motor Ship*, 32, 46 (1951) May.

In order to prevent the corrosion of cargo tanks a specially devised dehumidified ventilating unit has been installed in the new 6,300-ton tanker *British Warrior*. Although this is the first British-built tanker to have such a unit fitted, the installation cannot be regarded as an experiment, as four U. S. vessels have been similarly equipped and apparently with good results. Generally speaking, a large tanker is in need of structural renewals after shipping about 100 cargoes, and the life of the tanks of an oil tanker engaged in the trans-Atlantic trade is about seven to eight years. Records show that one 12,000-ton Shell tanker was so badly corroded after seven years' service that the cost of renewing bulkheads amounted to some £180,000. There are, of course, various coatings, paints and compositions which may be applied, but they cannot be regarded as a permanent answer to the problem. Suggestions are being put forward for spraying the interiors of the tanks with an aluminum coating, and there are many who believe that light-alloy cargo tanks, admittedly expensive, would solve the problem. The Cargocaire installation is claimed to reduce maintenance costs due to corrosion by about 80 percent. This is apparently based on experience with the American tanks and, if confirmed, represents an appreciable economy. If the system is successful in extending the life of the tanks by only four or five years, the extra freight earned by carrying spirit instead of black oil should more than pay for the initial expenditure and running costs of the installation.—TIME.

per car
the char-
ric con-
ted, the
sition of
obtained
various
inds of
ed with
ts of a
hopper
tings of
found
ospheric
and a
1½ in
ganese-
atmos-
g of 2,
higher
slightly
per car
ce of a
atmos-
ting of
to that
steel, is
copper
bodies
er steel
own that
occur in
permit
ad fines,
g mem-
igations
e maxi-
sed for
the car
ly with
aterial.

Motor
sion of
sed de-
open in-
tanker
is the
such a
t be re-
U. S.
ped and
generally
need of
g about
ranks of
trans-
o eight
0,000-ton
ed after
t of re-
o some
various
s which
t be re-
to the
put for-
of the
ug, and
t light-
pensive,
rgocaire
mainte-
y about
ased on
nks and
reciable
ssful in
by only
freight
ead of
for the
costs of



Available in Durimet 20,
Durco 18-8-S-Mo and a
wide range of other
Durco stainless alloys.

DURCO TYPE F VALVE

When you buy a valve, you're mainly interested in trouble-free performance. This valve gives it to you—in the toughest kinds of chemical service. There are thousands in use. Yet, no case of sticking has ever been reported, despite the fact that no lubricant is used.

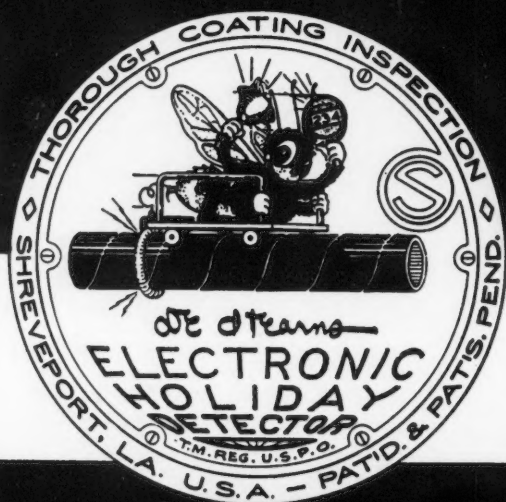
The reason is the Teflon sleeve—and the basic design that makes it practical to use. Sizes ¼" through 2". Other details in Bulletin 647.



A product of
THE DURIRON COMPANY, Inc.
Dayton, Ohio

Attend
NACE
Convention

Hotel Sherman
Chicago
March 16-20, 1953



The D.E. STEARNS *Company*

SHREVEPORT, LOUISIANA U.S.A.

BETTER COATINGS CONSERVE STEEL

